WATER PLANT OPTIMIZATION STUDY

HAMILTON WATER TREATMENT PLANT

JANUARY 1994

Ontario

Ministry of
Environment
and Energy

ISBN 0-7729-3298-0

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n'est disponible qu'en anglais.

PIBS 2778

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Please note that some of the recommendations contained in this report may have already been completed at time of publication. For more information, please contact the local municipality, or the Water Resources Branch of the Ministry of Environment and Energy.

Note, all references to Ministry of the Environment in this report should read Ministry of Environment and Energy.

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EXECUTIVE SUMMARY

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This study of the Regional Municipality of Hamilton-Wentworth's Woodward Avenue Water Treatment Plant was conducted under the Water Plant Optimization Program of the Ontario Ministry of the environment. Included in this project were reviews of three years of plant operating and laboratory data, and an assessment of present conditions with emphasis on particulate removal and disinfection. Details of the raw water source, flow measurement, process components, plant operation and plant performance form the body of the report. The appendices contain the laboratory and plant data for 1984 to 1986, the results of jar test performed during this study, samples of daily and monthly logs kept at the water plant and a report on plant waste generation and disposal.

The Hamilton-Wentworth Water Treatment Plant employs treatment process with coagulation, sedimentation and filtration. Disinfection is achieved with the addition of chlorine prior to treatment; following filtration ammonia is added to change the form of chlorine from free to combined. The plant has the capacity to treat 873,000 m_3/day and it serves a population of 385,000 in Hamilton, Ancaster, Dundas, Stoney Creek and Waterdown. To save on electricity costs, the plant operates only at night on weekdays and 24 hours per day from Friday night to Monday morning.

The treated water is generally of very high quality. With respect to particulate removal, the average treated water turbidity for the study period (1984-1986) was 0.38 NTU. The bacteriological quality of the water is also good; no positive presence-absence test results were reported and no total plate count result exceeded 500 organisms/ml in the study months.

The staff of the Region are interested in optimizing the plant performance and in the past, several studies to investigate performance improvement methods have been initiated. Some of the recommendations in this report have been acted upon since the start of the study. The following is a summary of the recommendations:

1. **Flow measurement:** Assess the need to improve the accuracy of the flow measurement devices.

2. **Coagulant addition:** Establish a jar test procedure to determine coagulant addition.

3. **Streaming current detectors:** Investigate further the potential of streaming current detectors to optimize coagulation.

4. **Laboratory reporting:** Improve the reporting system to make the data more available for review and evaluation.

5. **Routine laboratory analysis:** Review the routine analyses in terms of usefulness and necessity.

6. **Chlorine residual measurement:** Develop a data base of the form(s) of the treated water chlorine residual.

7. **Raw water sample line:** Determine if changes in water quality occur in the laboratory raw water sample line, and if so increase the water velocity.

8. **Maintenance/Operations responsibilities:** Review the policy prohibiting operations staff from calibrating instruments.

9. **Consumer complaints:** Set up a recording and mapping system for consumer complaints in order to recognize trends.

10. **Operating schedule:** Review the current "stop/start" operating schedule.

INTRODUCTION & TERMS OF REFERENCE

INTRODUCTION AND TERMS OF REFERENCE

The Ontario Ministry of the environment has established two co-ordinated programs for the study of drinking water treatment in Ontario. The Drinking Water Surveillance Program is a continuously updated base of information on the water plant facilities and monthly analysis of raw and treated water quality. Each plant in the Surveillance Program is also part of the Water Plant Optimization Study. The purpose of this study is to "document and review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on the removal of particulate materials and disinfection processes."

To this end, a protocol and terms of reference were prepared for the Plant Consultants. Each study consists of eight work tasks which include:

- documentation and review of three years of water plant and laboratory data
- assessment of plant operations and efficiency in particulate removal
- assessment of disinfection practices
- possible short and long-term process modifications to obtain optimum water quality

The Woodward Avenue Treatment Plant, located on Woodward Avenue in Hamilton, draws water from Lake Ontario southeast of the outlet from Hamilton Harbour. The water is treated and supplied to a population of approximately 385,000 in Hamilton, Ancaster, Dundas, Stoney Creek and Waterdown. A water supply facility has been located on the site since 1859. The Region also operates seven wells which serves Greensville, Carlisle, Freelton and Lynden. These water systems are not part of this study.

The operating schedule of this plant is unusual; in order to reduce hydro costs, the Hamilton-Wentworth Water Plant operates only at night during the week. In Hamilton, Hydro experiences two peak demand periods Monday to Friday, one at approximately 0800h and another at approximately 1800h and shuts down at 0745 Monday to Friday; it operates continuously from Friday evening through to Monday morning.

To evaluate conditions at the plant, water quality and quantity data from the years 1984, 1985 and 1986 have been used in this study. Daily values of chemical dosages and water quality measured at the water plant were available in the form of monthly summaries. However, the raw and treated water quality data from the Hamilton-Wentworth Regional laboratory was listed on individual daily sheets and it was not in a readily useable form. No daily, monthly or yearly summaries were available. Three representative months of data from each year were used to cover the major seasonal conditions. The months selected for this purpose were April, July and December.

The Hamilton water plant consists of two separate treatment modules (see Figure 1). Each module is a complete treatment system which can be operated independently. The treated water from both modules is mixed in the clearwells which are connected. Module 1 is located on the west side of the plant and includes filters 1 to 12. Module 2 is on the east side and includes filters 13 to 24.

Figure 2 is a site plan of the water treatment plant. The low lift station is located adjacent to the lake. From there, the water is pumped approximately 550m under the Queen Elizabeth Way highway to the treatment plant. The Woodward Avenue Sewage Treatment Plant; the Regional Laboratories, where the water analyses are performed, are housed in the main control building of the sewage treatment plant.

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
WATER TREATMENT PLANT

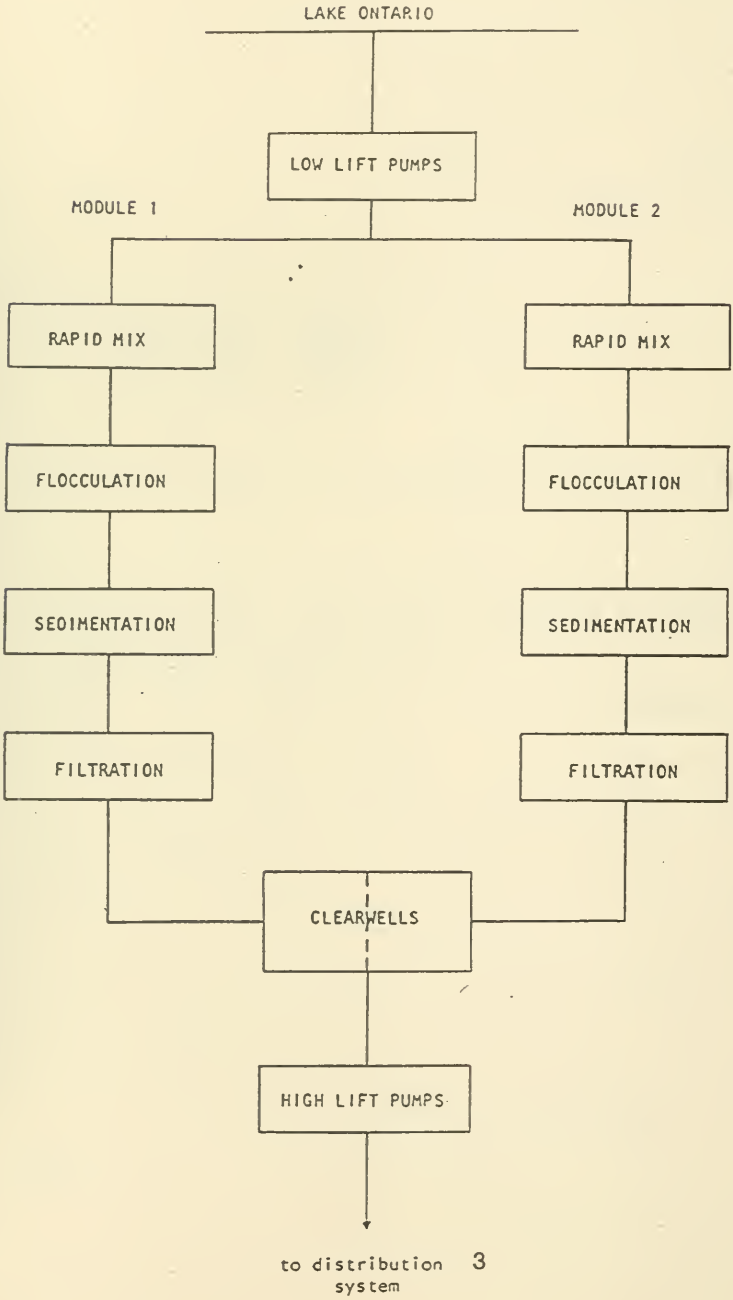
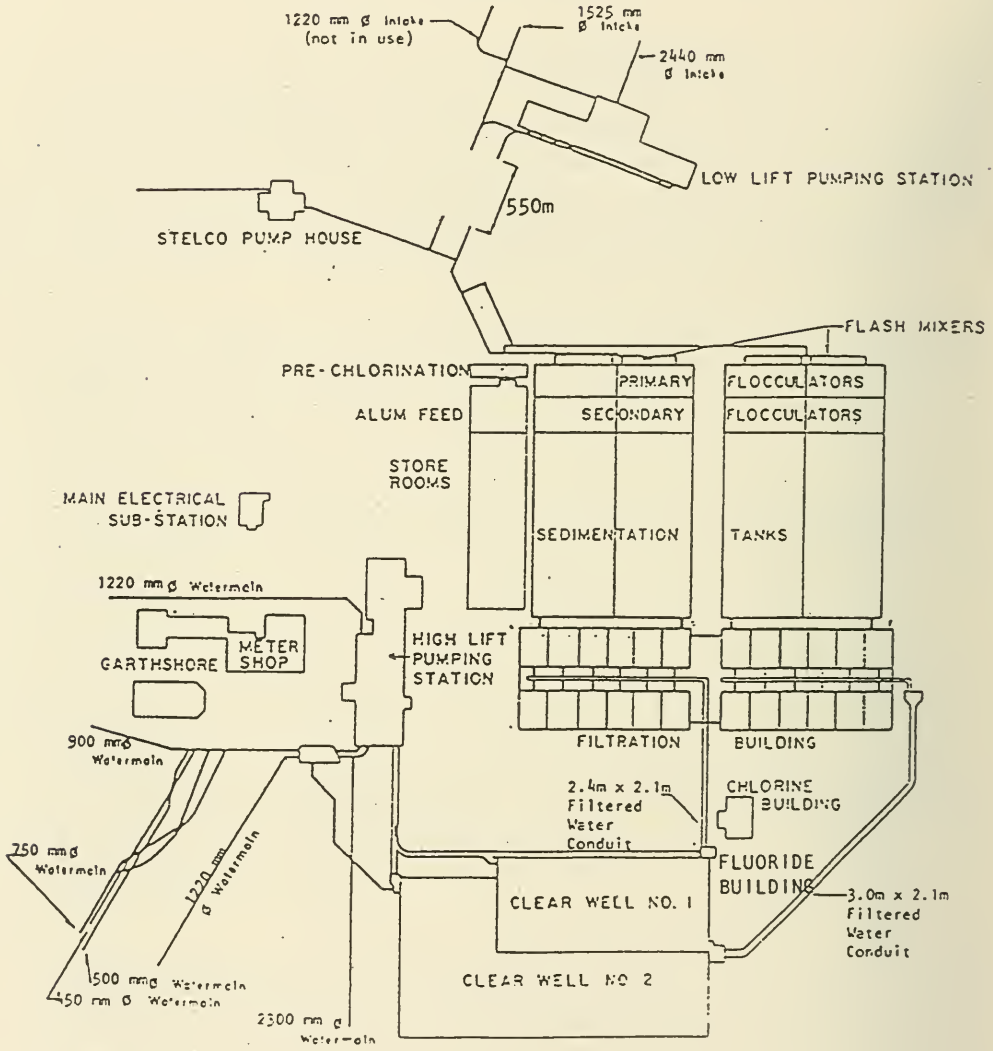


FIGURE 1

HAMILTON-WENTWORTH WATER TREATMENT PLANT



To Woodward Avenue Sewage Treatment Plant and Regional Laboratory

FIGURE 2

Site Layout

SECTION A

RAW WATER SOURCE

A. RAW WATER

A.1 Source

The water source for the Woodward Treatment Plant is Lake Ontario. The intakes are located off the southwestern shore of the lake, southeast of Hamilton Harbour (see Figure 3). There are two intakes in service, one concrete and one steel, (914 m respectively and 945 m in length and 1525 mm to 2440 mm in diameter respectively. The intake cribs are approximately 6 m off the lake bottom in approximately 15 m of water. (see section C.3(a)).

Hamilton Harbour has been designated as an "Area of Concern" by the International Joint Commission due to poor sediment and water quality. Because the water plant intakes are close to the Harbour, there is concern that contaminants in the plume emitted from the Harbour through the Burlington Ship Canal, can or do reach the intakes. An October 1986 publication by the Ministry of the Environment entitled "Impact of Hamilton Harbour on Western Lake Ontario" includes the results of a 1982 investigation of the plume and the Hamilton water intakes.

For the impact study, weekly samples of raw water were taken directly from the Hamilton intake pipe from May 20 to September 1, 1982 and were analyzed for parameters determined to be characteristic of the canal water and the plume. Additional samples were collected from the intakes when specific surveys of the plume were being carried out.

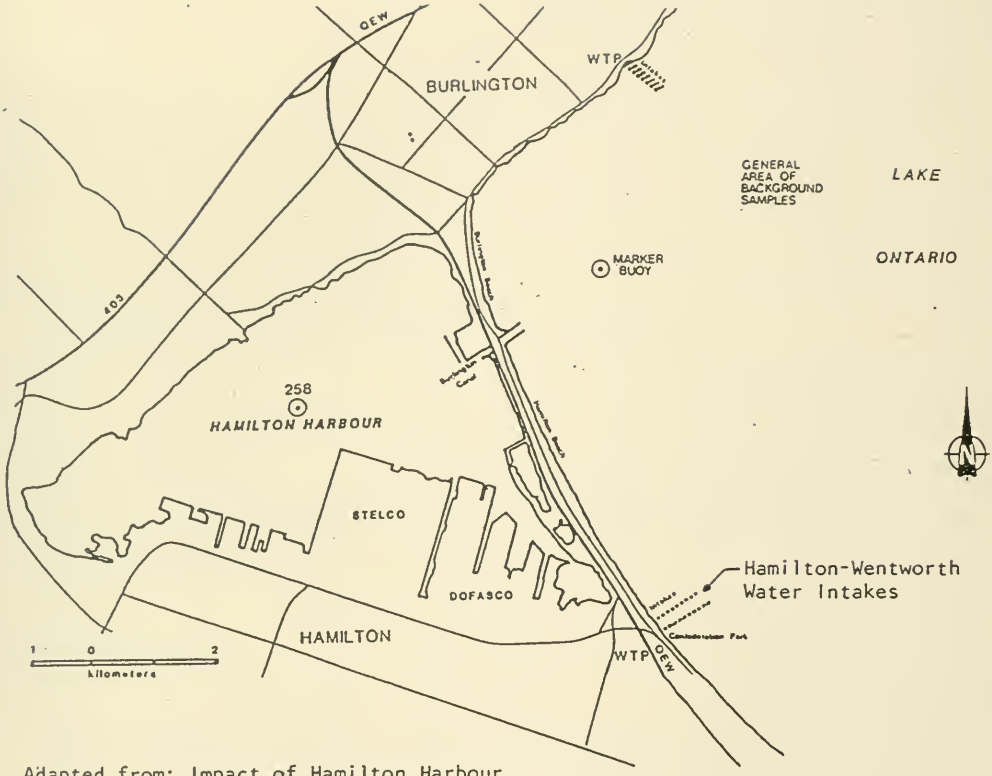
The results of this study are inconclusive. Nutrient levels on some dates "indicate possible plume impingement on the intakes", but the elevated ammonia levels found during a storm in May 1982 may have been caused by run-off or by transport from other areas of the lake.

Elevated levels of heavy metals occasionally found in the raw water were "most likely from sources other than the Harbour".

While the report does call for more extensive monitoring and investigation, the data collected does indicate that the plume from the harbour may reach the Woodward Treatment Plant intakes occasionally.

The following is an excerpt from the summary and conclusions section of the report, page 1-5:

> Although average water chemistry data at the Hamilton and Burlington Water Treatment Plant (WTP) intakes are not significantly different from those measured at lake background locations, occasionally high results were found at the intakes for nutrient (N and P), heavy metals and turbidity. Burlington WTP results assessed in conjunction with plume survey data suggest impingement of the harbour plume on one survey date, while for another date, plume data suggest impingement at the Hamilton WTP intake (no intake data available). Increases of turbidity and associated heavy metals occasionally observed after rainfall are most likely due to runoff and storm-induced sediment resuspension, and are not likely attributable to the harbour discharge.



Adapted from: Impact of Hamilton Harbour on Western Lake Ontario, MOE, October, 1986.

FIGURE 3

Site and Intake Location

A.2 Quality

A.2(a) **Physical and Chemical Parameters**
(Regional Laboratory Analysis)

Although concern has been expressed about the possibility of a plume from Hamilton Harbour reaching the water plant intakes, the raw water quality at the plant is still good and it is quite consistent. In the years of 1984 to 1986 in April, July and December, the range of raw water quality physical and chemical parameter were as follows:

	Minimum	Maximum	Range of Monthly Mean
Turbidity (NTU)	0.6	33	0.9-4.1
Ammonia (mg/L)	0.01	0.26	0.02-0.05
pH	6.70	8.03	7.30-7.77
Alkalinity (mg/L as $CaCO_3$)	80	133	92-100
Total Hardness (mg/L as $CaCO_3$)	122	152	125-138
Chloride (mg/L)	22.5	32.5	24.0-27.4
Fluoride (mg/L)	0.10	0.34	0.18-0.21

Turbidity

Turbidity varies somewhat with the weather. The usual raw water turbidity is <5 NTU, however, during storms with easterly winds off the lake, the turbidity tends to rise.

Ammonia

During the months of study, the normal range of ammonia in the raw water was 0.02 to 0.05 mg/L. The occasional rise in ammonia levels are probably storm related (see Section A.1).

pH

The pH of the raw water is quite constant; it is usually between 7 and 8 units with very occasional variances below or slightly above this range.

Alkalinity

The range of monthly mean raw water alkalinity during the study months was 92 to 100 mg/L as $CaCO_3$. The alkalinity does not vary widely and is seldom below 85 mg/L or above 105 mg/L as $CaCO_3$.

Total Hardness

The total hardness of the raw water ranged from 122 to 152 mg/L as $CaCO_3$ with a range of monthly means of 125 to 138 mg/L as $CaCO_3$. The water is average hardness.

Chloride

Chloride concentration in the raw water is quite constant with a monthly mean range of 24.0 to 27.4 mg/L. This is well below the maximum desirable concentration of 250 mg/L.

Fluoride

The concentration of fluoride in the raw water is fairly constant at approximately 0.2 mg/L.

A.2.(b) Bacteriological Parameters (Regional Laboratory Analysis)

The bacteriological quality of the raw water for the study months of April, July and December, 1984-1986 is summarized below. The tables show the results in terms of percentage of all samples analyzed.

Total Coliforms (# organisms/100 ml)					
	0	1-5	6-100	101-5000	>5000
Percentage of All Samples Analyzed	20	35	41	4	0

Total Coliforms (# organisms/100 ml)					
	0	1-5	6-100	101-5000	>5000
Percentage of All Samples Analyzed	53	38	3	6	0

A.2(c) Drinking Water Surveillance Program, 1986

The following is an excerpt from the DWSP Annual Report - 1986, Plant Summaries (MOE, May 1987). The only parameter which was found to exceed the Ontario Drinking Water Objectives was organic nitrogen (2 samples).

HAMILTON WATER TREATMENT PLANT

EXECUTIVE SUMMARY
DRINKING WATER SURVEILLANCE PROGRAM, 1986

The Hamilton Water Treatment Plant was sampled 5 times in 1986; results are given for raw and treated samples.

The parameters analyzed fall into several categories: physical parameters and general chemistry, bacterial parameters, metals and organic substances including volatile and chloraromatic substances and pesticides.

The dicussion of results focuses on health-related parameters found in treated water:

(a) Organic Substances

Analysis was carried out for approximately 110 organic compounds. The only volatile compounds found, trihalomethanes (THMs) were always present in treated waters; the highest level recorded for total THMs was 29 µg/L.

(b) Other Parameters

The aesthetic ODWO* for organic nitrogen was exceeded in two treated water samples. Of the other physical, general chemistry and microbiological parameters and metals analyzed, for which there are health-related ODWO, none exceeded the objectives in treated water.

The results of these analyses are consistent with those obtained in other areas of the Great Lakes.

The treated water from the supply did not exceed any known health-related guideline for organic substances applicable to drinking water.

* The Ontario Drinking Water Objectives, revised 1983.
(from Drinking Water Surveillance Program, Annual Report - 1986, Plant Summaries, MOE, May 1987.)

HAMILTON WATER TREATMENT PLANT

SUMMARY TABLE OF RESULTS
DRINKING WATER SURVEILLANCE PROGRAM, 1986

The Hamilton Water Treatment Plant was sampled 5 times in 1986.

PARAMETER CATEGORY	Type of Sample	
	Raw	Treated*
1 GENERAL CHEMISTRY-includes anions such as sulphate, field analyses such as chlorine residual and physical parameters such as colour.		
Total number of parameters in category: 21		
- Total number of analyses completed	90	90
- Total number of positive results	82	72
- Number of time guidelines exceeded	N/A	2
2 METALS-includes metals such as copper and lead.		
Total number of parameters in category: 24		
- Total number of analyses completed	108	108
- Total number of positive results	58	54
- Number of time guidelines exceeded	N/A	0
3 BACTERIOLOGY-includes bacteria such as coliforms.		
Total number of parameters in category: 5		
- Total number of analyses completed	20	20
- Total number of positive results	15	1
- Number of time guidelines exceeded	N/A	0
4 VOLATILES-includes compounds such as benzene and toluene; also included in this category are trihalomethans (5 parameters), acknowledged to be produced during water treatment.		
Total number of parameters in category: 29		

- Total number of analyses completed	140	141
- Total number of positive results	4	16
- Number of time guidelines exceeded	N/A	0

5 PESTICIDES-

Total number of parameters in category: 65

- Total number of analyses completed	180	180
- Total number of positive results	0	0
- Number of time guidelines exceeded	N/A.	0

6 CHLOROAROMATICS AND CHLOROPHENOLS-includes a range of chlorinated organic compounds.

Total number of parameters in category: 19

- Total number of analyses completed	71	71
- Total number of positive results	0	0
- Number of time guidelines exceeded	N/A	0

* Total number of analyses completed will not always equal the number of parameters analyzed for multiplied by number of times the supply was sampled, because of accidents during shipping or analyses or analytical difficulties.

** Ontario Drinking Water Objective

* (From: Drinking Water Surveillance Program, Annual Report - 1986, Plant Summaries, MOE, May 1987)

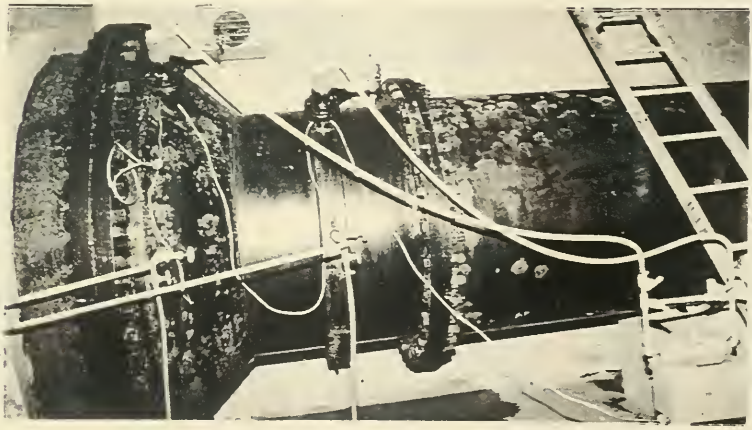
SECTION B

FLOW MEASUREMENT

B. FLOW MEASUREMENT

The following sections provide a general description of the flow measuring devices through the plant. Details and specifics of this equipment are contained in the table at the end of this section.

B.1 Raw Water



VENTURI FLOW METER

From the Low Lift Station the raw water is pumped approximately 550 m to the treatment plant. Some of the raw water is piped to the Stelco Pumping Station (see Figure 2). When the water treatment plant is operating, Stelco receives raw water from the Low Lift discharge pipe. However, when the water plant is not operating (during the day on weekdays), Stelco draws water back out of the flocculation and sedimentation tanks. The quantity of water Stelco uses is measured by a venturi meter located on the discharge pipe from the Stelco pumping station; the average flow to Stelco is 68,000 m^3/d.

When the raw water reaches the treatment plant it is split in half to supply water to the two treatment modules. The flow to the modules is measured by a cast iron venturi meter installed in each of the two pipes. Venturi measures flow by producing a difference in head between two points and the differential is a function of velocity. These measurements provide raw water flow figures which are electrically transmitted to the filter building control panel. The differential pressure and flow relationship for these venturis is as follows:

	RATED		TEST HEAD	
	HEAD (mm)	FLOW (1000 m^3/d)	HEAD (mm)	FLOW (1000 m^3/d)
MODULE 1	727	455	182	227
MODULE 2	911	455	228	227
STELCO	10260	114	1642	45

The raw water flow which is recorded on the daily log is modified to reflect water taken by Stelco. During the day, when the plant is not operating, Stelco draws water out of the flocculation and sedimentation tanks. (This water has passed through the raw water venturis).

A low lift pump is turned on periodically during the day to refill the flocculation and sedimentation basins. The net raw water flow recorded is calculated from the following:

Raw Water Flow = (Total Raw Water Venturi Flow)-
(Stelco's average hourly pumpage x the number of hours a low lift pump was not on).

B.2 Treated Water

The discharge pipe from each High Lift Pump is equipped with a flow meter and transmitter. Pumps 1 to 4 have venturi meters and pumps 5 and 6 have restriction orifices. The signals from the transmitter are sent to the High Lift Station Control Panel where the flows are totalled, recorded on a chart and the cumulative total is displayed. The rated and test heads of these meters are as follows:

	RATED		TEST HEAD	
PUMP NO.	HEAD (mm)	FLOW (1000 m^3/d)	HEAD (mm)	FLOW (1000 m^3/d)
1	2418	182	944	114
2	2418	182	1849	159
3	2418	182	1849	159
4	2418	182	1849	159
5	6156	227	2210	136
6	5177	227	2537	159

B.3 Backwash Water

Filter effluent is pumped to the wash water tower. As the wash water is used, the flow from the tower is measured by a venturi meter. The flow measurement is translated to inches per minute rise of backwash water through the filter. This value is displayed on a meter located beside the Venturi below the tower on the main floor of the filter building. It is also sent via an electric signal to the overhead gauges in the filter galleries. Only one filter is backwashed at a time.

The water level in the tank is monitored and the water depth (in feet) is displayed on a meter beside the Venturi and on the gauges in the filter galleries. The water level sensing switches also control the backwash pumps which refill the tank as water is used.

B.4 Filter Effluent

The filter water flow is measured by Sparling Master Flo Propeller meters which are installed at the beginning of the filtered water conduits. The effluent pipe from each filter is also equipped with a venturi meter.

The total filtered water flow recorded daily on the Filter Building Log is not taken from any of the measuring devices, but is based on the following calculation:

Filtered Water Flow = (Total Treated Water Flow through the High Lift Pumping Station) + (backwash water used) ± (the net volume change in the clearwells)

The filter effluent measuring devices are part of an automatic flow control system.

FLOW METERING EQUIPMENT

SERVICE	NUMBER	TYPE & CAPACITY	LOCATION	INSTRUMENTATION
Raw Water	2	Venturis Module 1-2100mm x 1500mm Module 2-1800mm x 1200 mm Capacity (each): maximum 455000 m^3/d	Raw water conduit prior to rapid mix.	Local: Bristol transmitter Controller at local panel CFBCP: Bristol flow indicating recorder. Transmission integrator. Total raw water flow indicator. Valve position indicators
Stelco	1	Venturi Capacity: maximum 114000 m^3/d	Outside Stelco pumping station	Local: Bristol transmitter CFBCP: Flow indicator HLSCC: Bristol flow & pressure recorder. Flow integrator
Filter Effluent	2	Sparling Master Flo Propeller Flow Meters Capacity (each): maximum 455000 m^3/d	In filtered water conduits	Local: Sparling pulse transmitter CFBCP: Sparling totalizer indicating recorder
	24	Venturis-400 mm Capacity (each): maximum 45000 m^3/d	On effluent pipe from each filter	used for local filter rate control only (filter rate control valve section on filter control table)
Backwash	1	Venturi Capacity (each): maximum 327000 m^3/d	On discharge pipe from the wash water storage tank	Local: Bristol transmitter CFBCP: Bristol flow recorder
Treated Water	4	Venturi Capacity (each): maximum 182000 m^3/d	On high lift pump discharge pipes (pumps 1 to 4)	Local: Bristol transmitter CFBCP: Bristol total flow summator HLSCC: Bristol high lift flow indicator (0-990000 m^3/d)
	2	Restriction Offices Capacity (each): maximum 227000 m^3/d	On high lift pump discharge pipes (pumps 5S6)	

NOTES:

1. The flow meter instrumentation is calibrated so as to provide maximum accuracy in the normal operating range of the plant.
2. CFBCP = Central Filter Building Control Panel
3. HLSCC = High Lift Station Central Console
4. There is a minimum flow through a Venturi meter below which the accuracy of the flow measurements are unreliable. These minimum flows should be provided in the capacity range.

B.5 Validity

The flow measurements from the raw water venturis are questionable since neither meter was installed according to standard practices. A standard venturi tube consists of a reduction in pipe diameter, a section of constant pipe size, followed by an enlargement to the original pipe size. Sections of straight, uninterrupted pipe (calming links) are necessary both upstream and downstream of the venturi.

In both Modules 1 and 2, the venturis are followed closely by main flow control butterfly valves. When these valves are completely or partially open the valve plate would interfere with the measurement of flow through the venturi. Also, both venturis 1 and 2 lack the standard calming links upstream and downstream. In Module 2 the flow is measured through a reduction in pipe diameter (1830 mm to 1220 mm) but there is not an enlargement to the original pipe size.)

A flow calibration of these venturi would be necessary to test the accuracy of the measurements. The differential head is checked and calibrated annually by Maintenance Department staff, but the actual flow as it relates to this differential is not calibrated.

The validity of the treated water flow measurements is also questionable. The downstream calming links for the venturi following pumps 1 to 4 are short due to a "T" intersection in the discharge pipes. An estimate of the accuracy of the treated flow measurement cannot be made; calibrations of the venturis and orficies would be required. As with the raw water venturis, the Maintenance Department staff check the differential annually, but the actual flow is not calibrated.

The accuracy of the backwash water flow measurement by the venturi could be checked. With the backwash pumps off, the water level in the backwash water tank could be monitored and the change in volume compared to the flow measurement by the venturi.

The flow measurements from the venturis on each filter effluent pipe may not be accurate due to a lack of the recommended downstream calming pipe length; however, these values are not recorded. The flows measured by these venturis are used only for the flow control system (see Section D.1(b)).

SECTION C

PROCESS COMPONENTS

C. PROCESS COMPONENTS

C.1 General

Figure 1 is a block diagram which shows the basic components of the treatment process. The figure has been printed throughout the process component inventory section for easy reference. As mentioned earlier, the plant is divided into two independent treatment modules. When repairs or maintenance of a major component are required, the plant can operate using only one module. Figure 7, at the end of this section, is a detailed schematic of the complete process including chemical additions.

The plant is equipped with an automatic flow control system which monitors the level of water in the clearwells, the flow of filter effluent and the water level in the filtered water conduit. There are 30 control system loops (see Section D.1(b)). A computerized control system is currently being installed at the plant by Regional instrumentation staff. It is not yet operational.

C.2 Design Data

C.2(a) Plant Capacity

The plant was rated at 200 million imperial gallons per day (MIGD) or 909,000 m^3/day at the time of the last expansion in 1973. However, the filtration rate of 36,364 m^3/day for each of the 24 filters does not limit the capacity to 873,000 m^3/day (192 MIGD).

The daily water flows from 1984 to 1986 were as follows: (all units: 1000 m^3/d)

	RAW	TREATED
Average daily flow	304.9	283.5
Absolute maximum daily flow	616.9	591.1
Average maximum daily flow (average of monthly maximums)	476.4	449.5
Absolute minimum daily flow	100.0	76.8
Average minimum daily flow (average of monthly minimums)	182.7	169.6

A summary of the flows for the three years can be found in table 1.0, Appendix A.

The above figures show that the plant usually treats less than half of the volume of water it has the capacity to treat. However, since it is in operation for only 13 to 13.5 hours per day during the week, the flow through the plant during operating hours is close to capacity on high flow days.

At the beginning of each month, a pumpage rate for the month is selected based on a record of past water use. During then, the plant is operated at this rate unless there is an emergency or the level of water in the reservoirs drops more than 20% per day. The monthly cost of hydro is based on the peak use of power during the month, so the treatment plant staff only raise the pumpage rate during the month if it is absolutely necessary.

The set pumpage rates relate to a combination of high lift pumps. The low lift pumps are set to accommodate this high lift rate (see Section C.3(i)). If, for example, the monthly rate is 391 x 10^3 m^3/d (86 MIGD), the plant is always operated at this rate. Thus, Monday to Thursday nights when the plant is operating for 13 to 13.5 hours, approximately 220 x 10^3 m^3 (48 MIGD) of raw water is treated.

On weekends when the plant is in operation 24 hours per day, the daily volume of raw water treated is 391 x $10^3 m^3$. During the week the reservoir levels are allowed to fall somewhat (up to 20% drop in level per day) and they are refilled on weekends.

C.2(b) Per Capita Flow

Limited information regarding per capita flow rates is available. Only some of the households in the Region are metered and the records department makes no differentiation between single family homes and multi-unit buildings. The systems Department at the Region estimates that 60 percent of the treated water is used by industry with the remaining 40 percent going to residential use.

The population served is approximately 385,500 m^3, the average total residential per capita flow is 295 litres per capita per day. Table 1.1 in Appendix A shows maximum and minimum per day. Table 1.1 in Appendix A shows maximum and minimum per capita consumption rates for 1984 to 1986.

In order to gain more information regarding per capita water use, flow records from the Woodward Avenue Sewage Treatment Plant were also obtained. However, the average daily sewage flow in 1984-86 was 313,000 m^3/day which is greater than the treated water flow. This is due to infiltration and possibly discharges from industries which have a separate water source. Therefore, the sewage flow data is not helpful in assessing per capita water use.

For comparison, the following table shows per capita water use in some Ontario municipalities.

	Population	Water Use (Lcpd)
Ajax	23,300	456
Barrie	34,000	584
Newmarket	21,000	387
Cambridge	70,000	539
Hamilton	385,000	736 (total) 295 (estimated residential)

C.3 Process Component Inventory

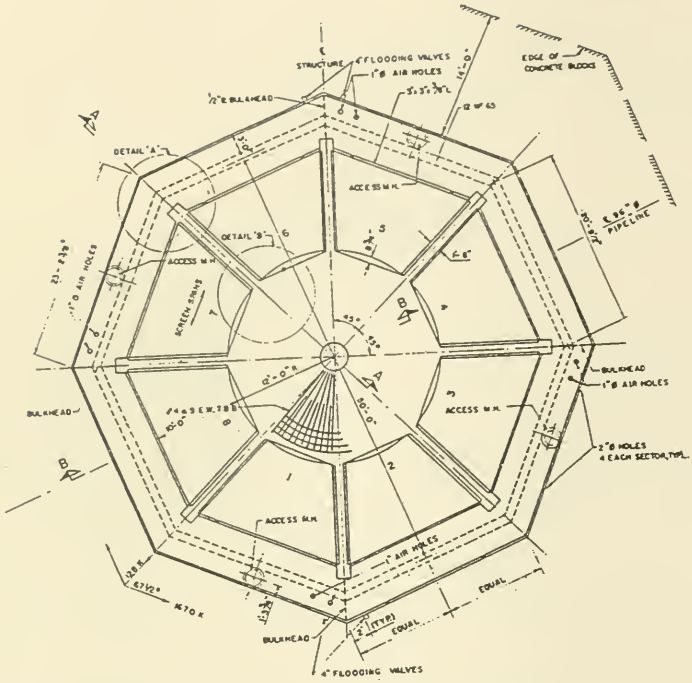
LOW LIFT PUMPING STATION

C.3(a) Water Intakes

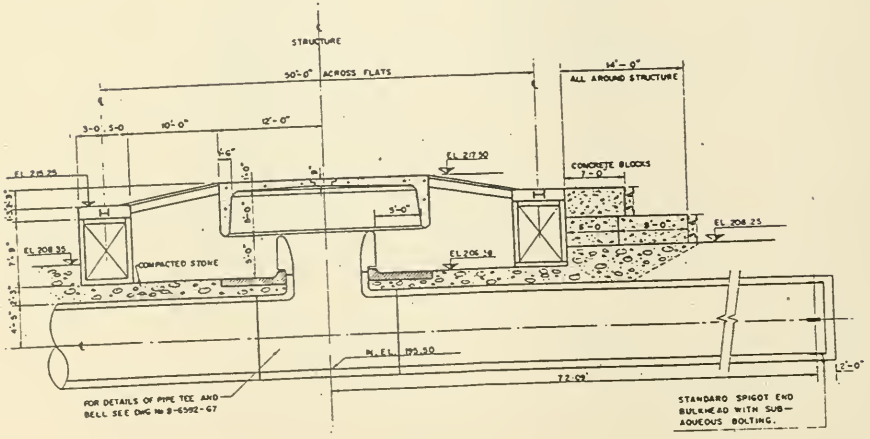
There are three intake pipes with two in use at the present time: Figure 3 on page 6 shows their location. The pipe specifics are as follows:

Diameter (mm)	Length (m)	Volume (m^3)	Material
2440	945	4419	concrete
1525	914	1669	steel
1220	640	748	steel (not currently in use)
Total Volume: 6836 m^3			

The crib structures at the opening of each pipe are approximately 6 m off the bottom in approximately 15 m of water. The largest intake (2440 mm diameter) is the newest; it was constructed in 1967. The crib on this pipe is an octagonal structure made of concrete and fibreglass and designed for protection against fazil ice. It has an intake port area of 81.2 m^2 and an inlet diameter of 3.7 m. Drawings of this crib structure follow:



PLAN

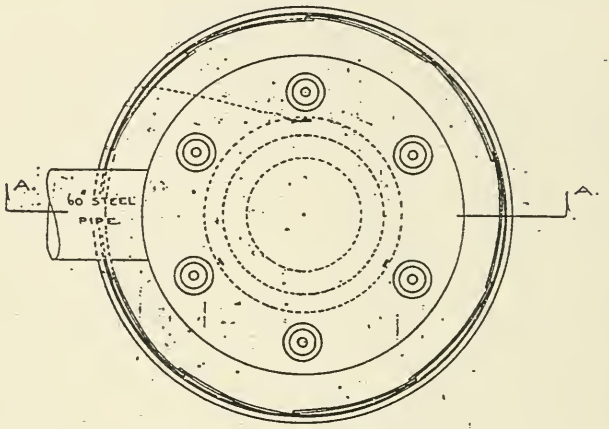


SECTION

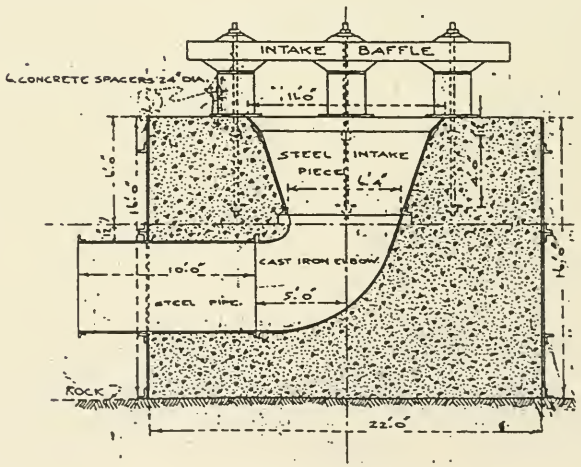
FIGURE 4

2440mm Ø Intake Crib

The 1525 mm intake crib was designed by the City of Hamilton Public Works Department and constructed in 1927. Its design is shown in the following drawings.



— PLAN OF INTAKE CRIB. —



— SECTION A.A. —

FIGURE 5

1525mm Ø Intake Crib

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
WATER TREATMENT PLANT

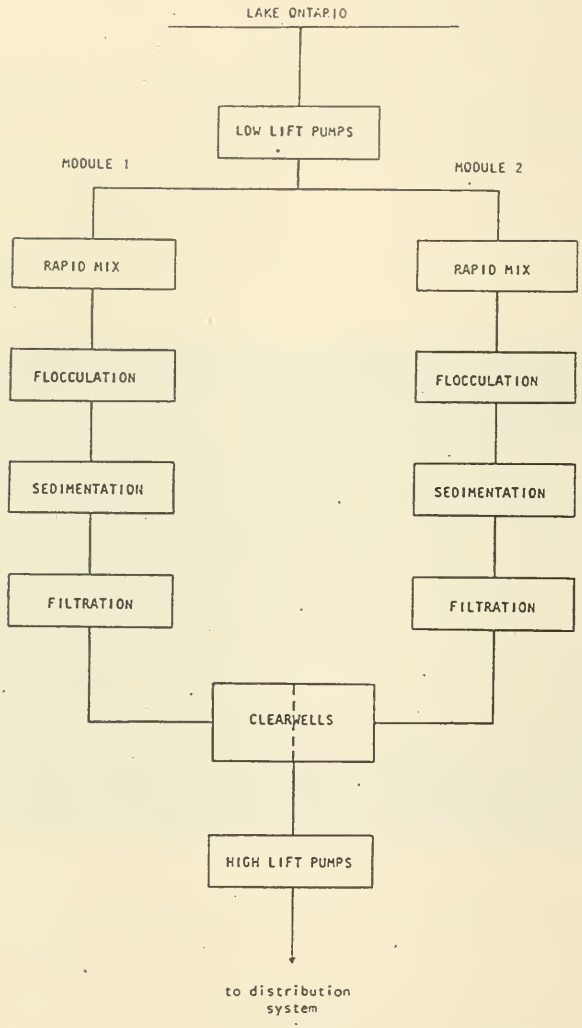
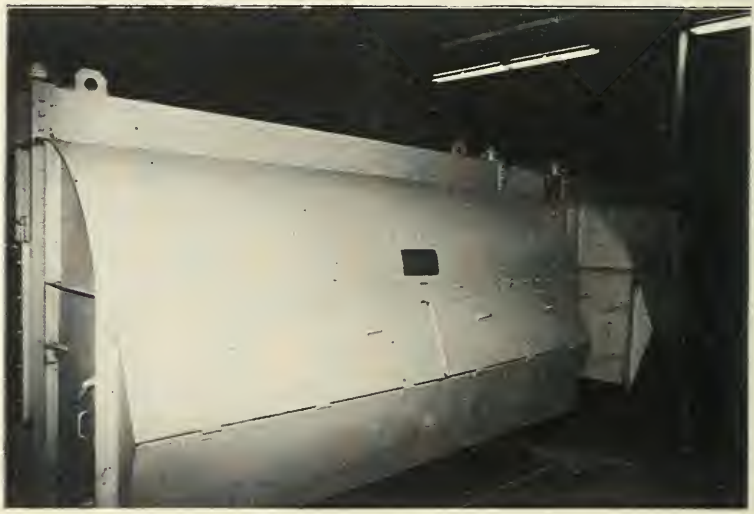


FIGURE 1
Process Block Schematic

C.3(b) Screening

Bar Screens:

These screens, which are located in the low lift intake chamber, prevent any large debris from entering the station. The opening size is 75 mm.



TRAVELLING SCREENS

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
WATER TREATMENT PLANT

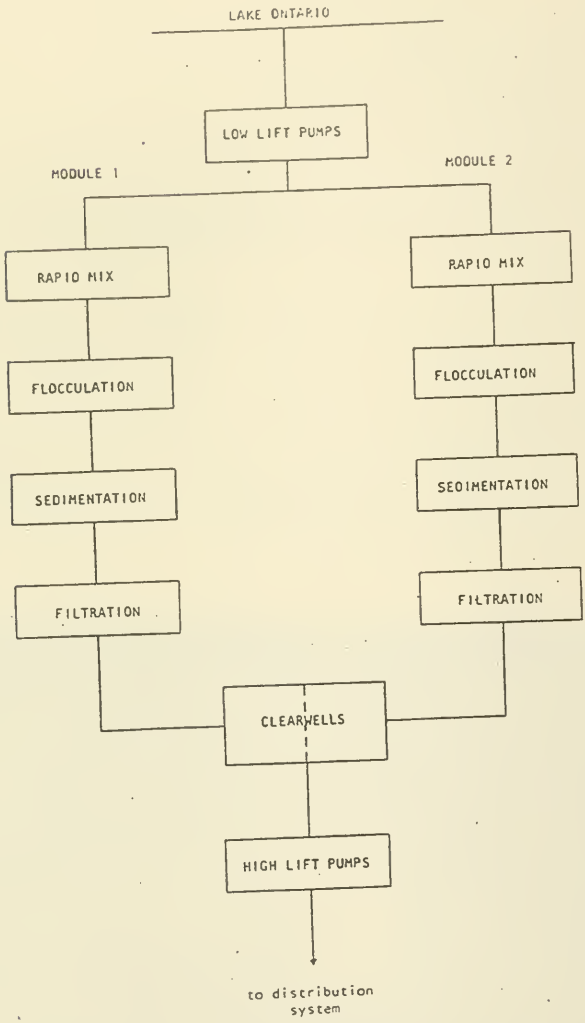
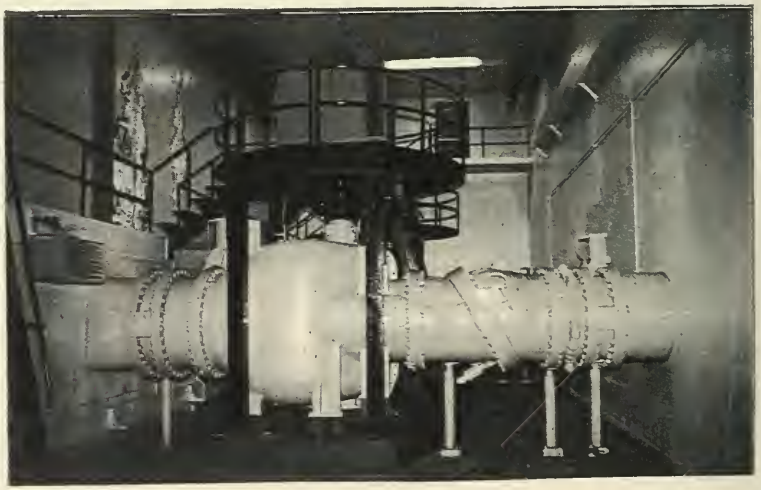


FIGURE 1
Process Block Schematic

Travelling Screens:

The water then passes through 6.4 mm brass mesh screens to remove smaller particles. There are three travelling screens manufactured by Link Belt, Model 454, Order Number TK 2795. Two screen wash jet pumps (40 HP Westinghouse Lifeline) located beside the Low Lift pumps are used to clean the screens; the waste water is collected in a sump and pumped to Red Hill Creek by two 15 HP Westinghouse Lifeline trash pumps.

The cleaning system is on a timer which initiates a six minute cleaning cycle once per hour. The screens are equipped with a differential pressure monitoring system with the pressure recorder located in the High Lift Station. However, when the cleaning of the screens was initiated by the pressure differential (headloss of 0.6 m),the screens were being damaged. There is less damage to the screens with the timed cleaning system. Manual initiation of the cleaning cycle is possible from the High Lift Building or the Low Lift Station.



LOW LIFT PUMP

SCHEMATIC
of
RAPID MIX, FLOCCULATION, SEDIMENTATION

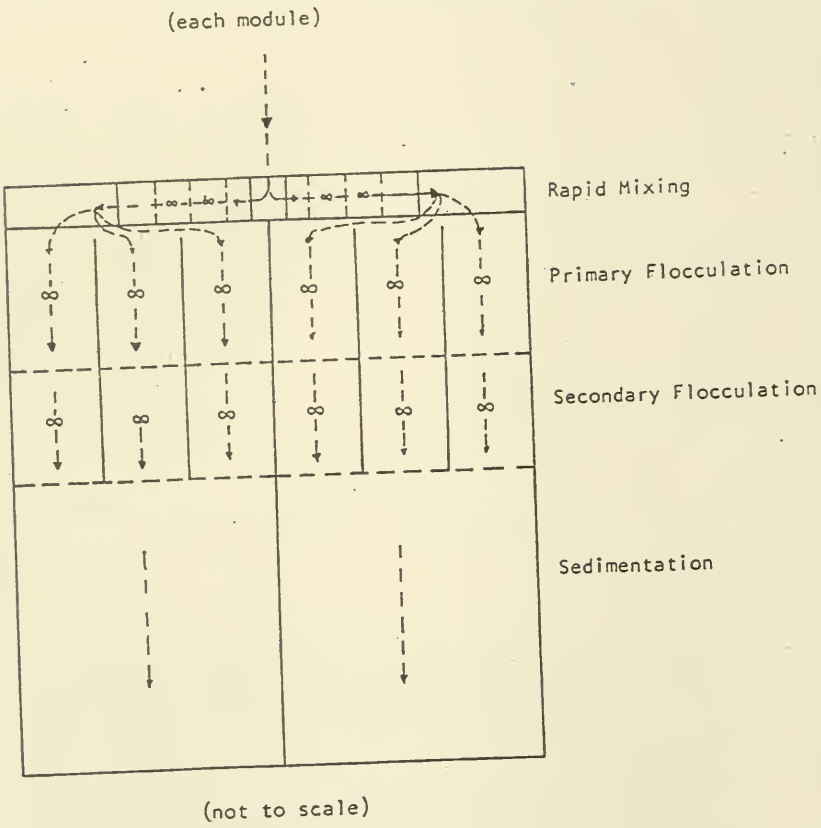


FIGURE 6
Schematic of Rapid Mix, Flocculation & Sedimentation

There are six Low Lift Pumps which pump the raw water from the lake to the beginning of the treatment process. The pumps were manufactured by Allis-Chalmers, (type LSV) and are equipped with Reliance Induction Motors. The units have the following ratings:

Pump No.	Capacity m^3/d	Head (m)	Power kW
1	227,500	8.5	262.5
2	163,800	8.5	187.5
3	227,500	8.5	262.5
4	163,800	8.5	187.5
7	259,350	8.5	262.5
8	259,350	8.5	262.5

There is space for two additional pumps (numbers 5 and 6).

The pumps can be operated one at a time or in any combination. The operator selects the number and combination of pumps to produce the desired flow rate. (See Section C.2(a)). The installed capacity of the station is 1.301×10^6 m^3/day; the firm capacity (without 1 of the largest pumps) is 1.042×10^6 m^3/day. The volume of the concrete low lift pump suction well is approximately 400 m^3.

C.3(d) Flash Mixing

Each module is divided into 2 sections for rapid mixing, flocculation and sedimentation. A schematic of these components, in Figure 6, is shown on the opposite page.

In each module the raw water enters an inlet well. The flow is then split and enters the rapid mix chambers via sluice gates at the bottom of the inlet well walls. (there are four rapid mix chambers, i.e. two per module).

Each rapid mix chamber has two mixers, separated by a baffle, which operate in series. The mixers are "Lightnin" by Greey Mixing Equipment Ltd., Model 84-WQ-25.

The chambers are each approximately 152 m^3 (to the top water level) which produces the following retention times:

Flow (1000 m^3/day)	Retention Time (minutes)	
	Night only operation	Continuous Operation
304.9 (average)	1.6	2.9
476.4 (maximum)	1.0	1.8
182.7 (minimum)	2.7	4.8

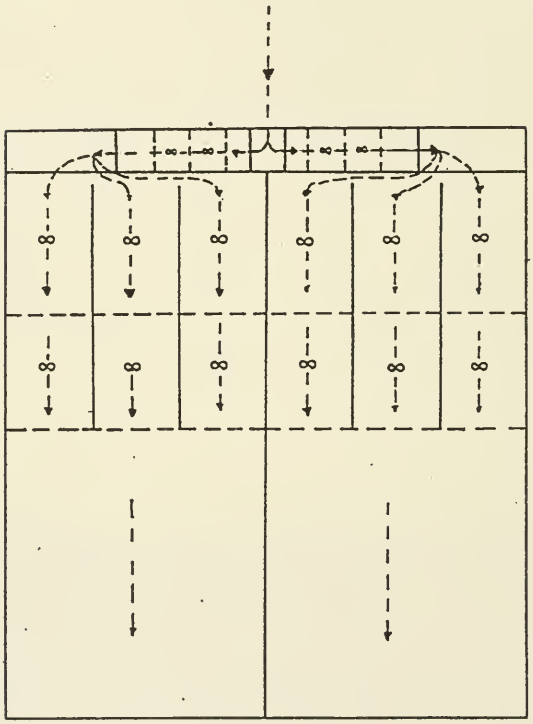
Because of the way the plant is operated, the high flow days most likely occur when the plant is in continuous operation on weekends. (see Section C.2(a)).

C.3e) Flocculation

FLOCCULATION MIXERS (PRIMARY AND SECONDARY)

SCHEMATIC
of
RAPID MIX, FLOCCULATION, SEDIMENTATION

(each module)



(not to scale)

FIGURE 6

Schematic of Rapid Mix, Flocculation & Sedimentation

At the end of each rapid mix chamber the water is fed into a conduit underneath the chamber. The water then flows into the bottom of the flocculation tanks. Each flocculation tank is divided into six cells. The three cells closest to the rapid mixers each contain one primary, high capacity flocculation unit. The other three cells in the tank each contain one secondary, moderate capacity flocculator. The primary and secondary units operate in series; the water flows from the primary cells to the secondary cells via 600 mm x 600 mm ports located approximately 600 mm below the top water level.

Each primary or secondary cell has a volume of 699 m^3 thus each of the four flocculation tanks has volume of 4194 m^3 (6 cells per tank, 2 tanks per module).

The retention times and velocity gradients for the flocculation units are shown in the following two tables:

Flocculator	Model No.	G (sec-)
Primary	84-Q-10	60
Secondary	84-Q-5	40

Plant Flow (1000 m^3/d)	Retention Night Only Operation	Time (minutes) Continuous Operation	Primary Unit Gt. Range	Secondary Unit Gt. Range
304.9 (average)	22.3	39.6	$8.0x10^4$-$1.4x10^5$	$5.4x10^4$-$9.5x10^4$
476.4 (maximum)	14.3	25.4	$5.1x10^4$-$9.1x10^4$	$3.4x10^4$-$6.1x10^4$
182.7 (minimum)	37.2	66.1	$1.3x10^5$-$2.4x10^5$	$8.9x10^4$-$1.5x10^5$

G values in the range of 20 to 74 sec^{-1} and Gt values between 2×10^4 and 2×10^5 have been found to produce satisfactory results in flocculation basins (R.L. Sanks, ed., Water Treatment Plant Design). The G and Gt values of the Hamilton plant fall within these ranges.

C.3f) Sedimentation

From the secondary flocculation cells, the water flows upward into small (70 m^3) chamber, then downward into the sedimentation tanks. A continuous target baffle is located in the sedimentation tank 600 mm from the port. There are four sedimentation tanks (two per module); each tank has a total volume of 11, 968 m^3. Retention times and overflow rates are as follows:

Plant Flow (1000 m^3/d)	Retention Time (minutes)		Overflow Rate (m^3/m^2-hr)	
	Night Only Operation	Continuous Operation	Night Only Operation	Continuous Operation
304.9 (average)	2.1	3.8	2.1	1.2
476.4 (maximum)	1.4	2.4	3.2	1.8
182.7 (minimum)	3.5	6.3	1.2	0.7

From the sedimentation basins, the water overflows into the settled water conduit.

C.3(g) Filtration

FILTER

(Not In Operation)

Backwash Troughs, Surface Wash Arm

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
WATER TREATMENT PLANT

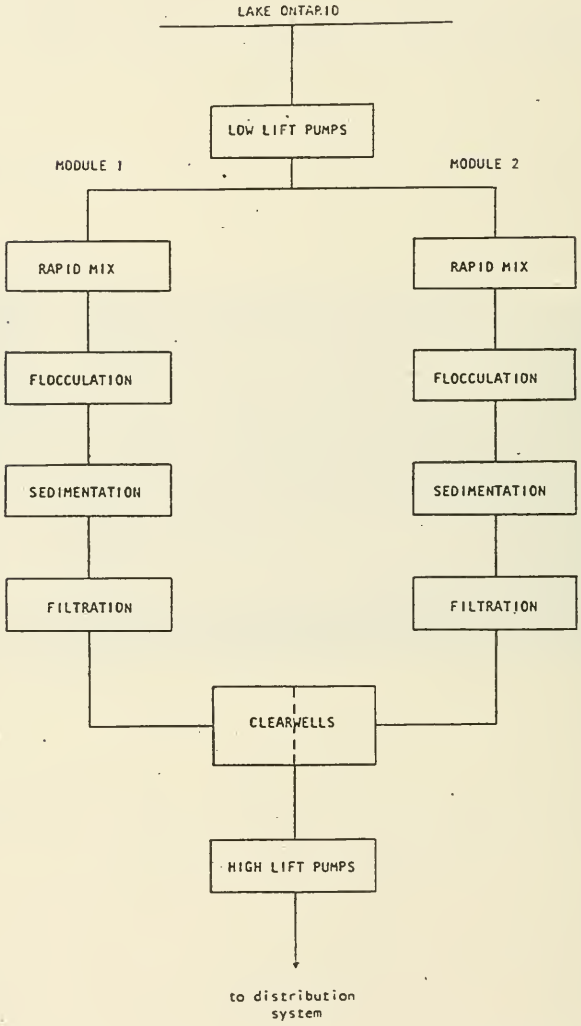


FIGURE 1
Process Block Schematic

Each module has 12 multi-media filters, each with a surface area of 132.9m^2. The filters are contained in concrete tanks with the following dimensions: 14.6m x 9.1m x 3.0m. The composition of the filters is as follows:

	Depth	Effective Size	Uniformity Coefficient
Anthracite	46 cm	0.70 mm	1.70-1.80
Sand	23 cm	0.48-0.55 mm	1.32
Gravel-Layer 1 2 3 4	 10 cm 5 cm 5 cm 5 cm	 3 mm-#10 mesh 6 mm-3 mm 13 mm-6mm 19 mm-13mm	
Total Depth	94 cm		

The underdrains are a Leopold block system which has 6 mm holes on 67 mm centres.

The wash troughs are pre-cast concrete, 66 cm wide on 1.8 m centres. The lip of the trough is 1.1 m above the top of the bed. Each filter is equipped with a Palmer sweep surface wash system.

The filters underwent a restoration in 1984-85, thus the old filters were in place during some of the period of study for this report. The filter rate with the former media was 8.6 m/hr. The old filter media consisted of:

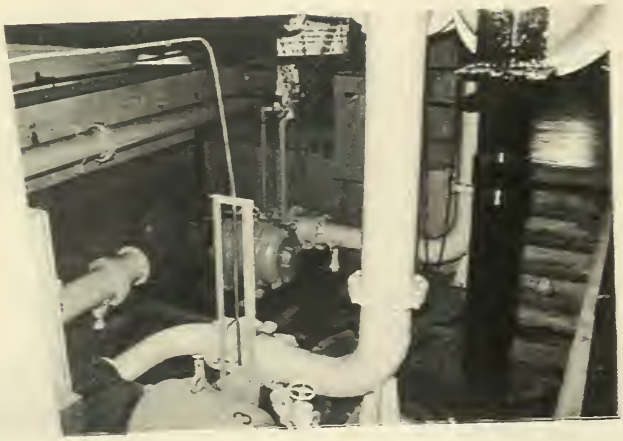
	Depth	Effective Size
Anthrafilt	38 cm	0.70 mm
Sand	33 cm	0.55 mm
Gravel (5 layers)	51 cm	6 cm to pea gravel
Total Depth	122 cm	

The following is filter operational data for the new filter media:

Influent Turbidity:	1-2 NTU
Effluent Turbidity:	0.10 NTU - maximum 0.4 NTU prior to backwash
Length of Run:	maximum 72 hours (since Feb. 1986)
Headloss (clean/dirty):	0.2-2.3 m
Flow Rate:	11.4 m/hr
Water Filtered per Cycle:	82.3 x $10^3 m^3$
Backwash Flow Rate:	18 m/hr - 42m/hr
Backwash Water per Wash:	600 m^3

The maximum length of a filter run was 36 hours until January 1986 when it was increased to 48 hours and then to 72 hours in February 1986. With the 36 hour filter run, an average of 255 backwashes were run each month, using a mean of 1.8% of the filtered water. Since the filter run was increased to 72 hours, the mean number of backwashes per month has decreased to 145 and the water use has decreased to a monthly average of 1% of the filtered water.

The filtered water is collected in two conduits, 1880 mm x 1980 mm, (one in each module) which are located in the centre of the set of filters. The filtered water then flow to the clearwells.



BACKWASH PUMPS

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
WATER TREATMENT PLANT

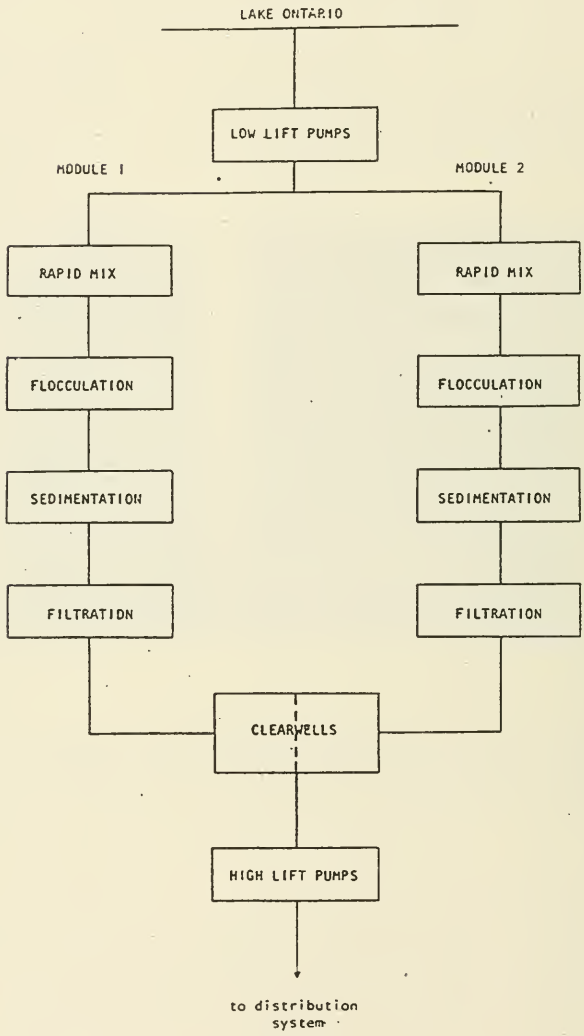


FIGURE 1

Process Block Schematic

Backwash pumps transfer filter effluent to a 450 m^3 storage tank in the tower on top of the building. The four pumps have the following ratings:

Pump No.	Location (East or West Wash Pump Well)	Capacity (m^3/d)	Head (m)	Manufacturer
1	West	25,900	27	Friarbanks Morse
2	West	25,900	27	Friarbanks Morse
3	East	13,180	21	Smart Turner
4	East	13,180	21	Smart Turner

When a backwash is initiated (see Section D./C), water flow by gravity from the tower to the filters.

C.3(h) Clearwells

CLEARWELLS (Buried)
Sewage Treatment Plant in Background

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
WATER TREATMENT PLANT

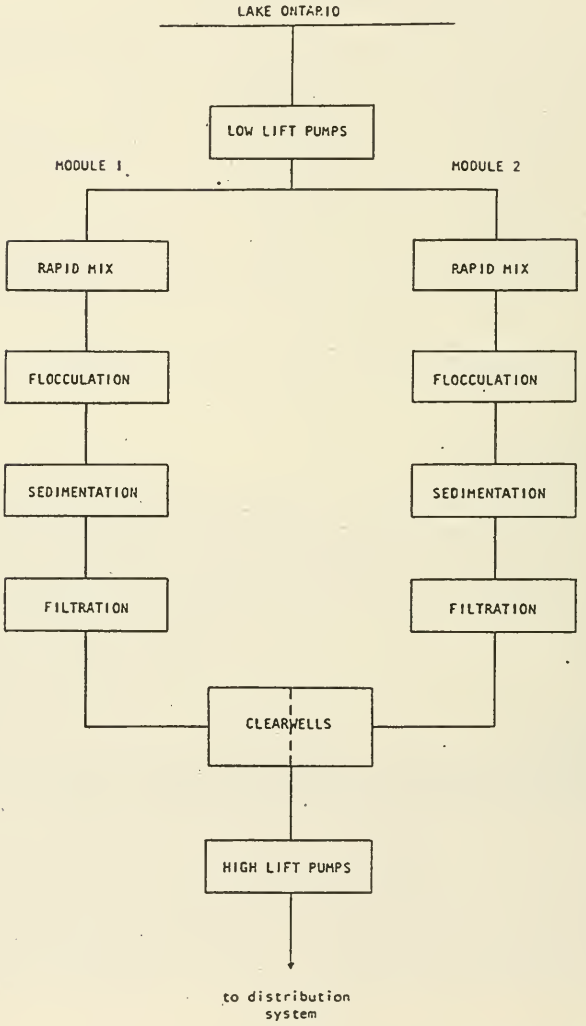


FIGURE 1
Process Block Schematic

There are two concrete clearwells which are fed individually, however, an interconnecting valve allows for balancing of the water levels. The total capacity of the clearwells is 27,200 m^3. Clearwell #1 which is the older, is 33 m by 90 m by 3 m deep. Clearwell #2 is L-shaped with a surface area of 6,100 m^2 and a depth of 3 m.

C.(i) High Lift Pumps

HIGH LIFT PUMPS

Six High Lift pumps are used to pump the finished water into the distribution system. Pumps 1 to 4 were manufactured by Canadian Ingersoll-Rand Co. Ltd. and have Westinghouse motors. Pumps 5 and 6 were manufactured by De Laval Turbine Inc. and are equipped with General Electric Motors.

The six pumps in the High Lift Station have the following ratings:

Pump No.	Capacity (m^3/d)	Head (m)	Power (kW)	Type
1	81,830	80	750.0	Centrifugal
2	136,382	80	1,312.5	Centrifugal
3	136,382	80	1,312.5	Centrifugal
4	136,382	80	1,312.5	Centrifugal
5	190,935	72	1,500.0	Centrifugal
6	159,113	72	1,500.0	Centrifugal

The High Lift pumps can be used singly or in combination. The High Lift operator chooses a combination of pumps which will produce the desired rate of flow.

The following list show the combinations of pumps used. These nominal pumpage rates vary from the actual capacity of the pumps.

PUMPAGE RATES FOR VARIOUS COMBINATIONS OF PUMPS IN HIGH LIFT

	1000 M^3/D	MGD
#1 PUMP	100	22
#2,#3 OR #4 PUMP	168	37
#5 OF #6 PUMP	187	42
#1 PLUS ONE OF #2,#3 OR #4	264	58
#1 PLUS #5 OR #5 PUMPS	286	63
2 PUMPS FROM #2,#3 OR #4	309	68
1 PUMP FROM #2,#3 OR #4 PLUS #5 OR #6	332	73
#5 AND #6 PUMPS	350	77
2 PUMPS FROM #2,#3 OR #4 PLUS #1 PUMP	391	86
1 PUMP FROM #2,#3 OR #4 PLUS #5 OR #6 PLUS #1 PUMP	409	90
#5 AND #6 AND #1 PUMPS	427	94
#2,#3 AND #4 PUMPS	455	100
2 PUMPS FROM #2,#3 OR #4 PLUS #5 OR #6 PUMP	477	105
1 PUMP FROM #2 OR #4 PLUS #5 AND #6 PUMPS	491	108
#1 PUMP PLUS 2 PUMPS FROM #2, #3 OR #4 PLUS #5 OR #6 PUMP	527	116
#2,#3 AND #4 PUMP PLUS #5 OR #6 PUMP	564	124
2 PUMPS FROM #2, #3 OR #4 PLUS #5 AND #6 PUMP	591	130

The installed capacity of the station is 841 x 10^3 m^3/d; the firm capacity (with the largest pump out of service) is 650 x $10^3/d$.

C.3(j) Backwash Treatment and Sludge Disposal

All backwash waste water is discharged to a 1200 mm diameter sewer leading directly to the nearby Woodward Avenue Sewage Treatment Plant. The washwater sewer discharges to the Hamilton Sanitary Trunk Interceptor just before it enters the main pumping station. Prior to 1980 the wash water was discharged to Red Hill Creek. A study of the plant waste is contained in Appendix D.

The sedimentation tanks are cleaned every 4 months on average. By that time 3 to 5 cm of sludge has accumulated. Only one basin is cleaned at a time, leaving 3 in operation. Approximately 4 m of water from the top of the tank is discharged to Red Hill Creek and the remaining water and sludge is sent to the sewage treatment plant. The sludge is flushed with high pressure hoses.

C.4 Chemical Systems

C.4(a) Disinfectant

Process

Disinfection of the water is achieved with chlorine and ammonia; a pre-treatment dose of chlorine is applied to the raw water and after treatment, ammonia is added to turn the chlorine residual from free chlorine is not combined chlorine. Pre-chlorine is added at a dose that will result in the maintenance of a free chlorine residual throughout the treatment process. This residual is then changed to combined chlorine and no post-chlorination is usually required. The desired finished water total chlorine residual is 0.80 mg/L and the pre-chlorine dose to maintain the residual is generally 1.5 to 3 mg/L. The mean ammonia dose is 0.21 mg/L.

When the plant starts operation in the evening, the chlorine residual from the pre-chlorination is sometimes low. This depends on the amount of water Stelco has used during the day, that is, on the length of time the water has been in the treatment plant following chlorination. If the residual is low, chlorine is added in the post-treatment stage for the first two hours of operation (approximately) to ensure the water has been sufficiently disinfected.

If the chlorine residual in the filter effluent is too high, the water can be dechlorinated with sulphur dioxide. However, the dechlorination system has rarely been required.

The desired form of combined chlorine residual is monochloramine which is formed in the following reaction of chlorine and ammonia in dilute aqueous solutions:

$$HOCl + NH_3 \rightarrow NH_2Cl \text{ (monochloramine)} + H_2O$$

This reaction occurs when the ratio of chlorine to ammonia is less than 5:1 by weight (at pH 7). If the ratio is larger, some of the monochloramine starts to form dichloramine by the reaction:

$$NH_2Cl + HOC0 \rightarrow NHCl_2 \text{ (dichloramine)} + H_2O$$

Some nitrogen trichloride (NCl_3), the third form of combined chorine, will form if the chorine to ammonia ratio reaches 15:1 by weight. (Handbook of Chlorination, G.C. White, 1972)

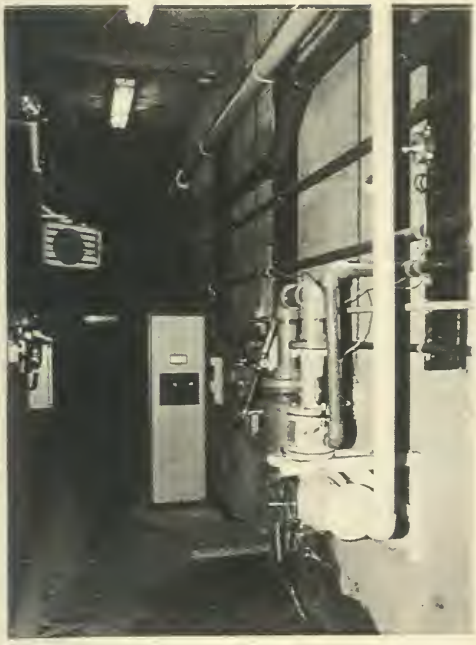
Monochloramine is not as efficient as free chlorine for disinfection, but a monochloramine residual lasts much longer than a free chlorine residual.

For this reason, the Hamilton water is first treated with free chlorine for disinfection and then the residual is changed to monochloramine to lengthen the life of the residual in the distribution system. It is important to prevent the formation of dichloramine and nitrogen trichloride because these compounds can cause taste and odour problems in low concentrations (0.08 mg/L and 0.02 mg/L respectively).

With a chlorine residual of approximately 0.8 mg/L and an ammonia dose of 0.2 mg/L, the form of continued residual should be monochloramine. A potential complication in this process is the presence of ammonia and organic nitrogen in the raw water. Because the pre-chlorine dose is high relative to the confrontation of these naturally occurring compounds, dichloramine and nitrogen trichloride may form during the treatment process.

Equipment

CHLORINE



PRE-CHLORINE INJECTION AND
CHLORINE ANALYSER

CHLORINE STORAGE TANKS

Liquified chlorine supplied by Stanchem for both the water plant and the sewage plant is stored in two 90-tonne tank cars located outside the water plant chlorine building. Four Wallace and Tiernan evaporators, type A785 each with a capacity of 3,600 kg/d, convert the liquid chlorine to gas for use at both plants. There is space available for a fifth evaporator if required in the future.

There are seven chlorinators, three for pre-chlorination (one for each module and one standby), two for post-chlorination and two for the sewage treatment plant. The water plant chlorinators have the following capacities:

Pre-chlorine:	Wallace and Tiernan type A821	1800 kg/d
Post-chorine:	Wallace and Tiernan type A721	227 kg/d

Before application, the chlorine gas is mixed with service water to form a chlorine solution.

Pre-chlorination takes place inside the raw water inlet pipe prior to rapid mixing. The chlorine gas is piped via 50 mm diameter vacuum lines to the rapid mix area. Injectors mix the gas with service water and the solution is piped 25 m into the water inlet pipe and added to the raw water through a 100 mm diameter solution diffuser.

The pre-chlorine dose is monitored by two Wallace and Tiernan chlorine analyzers which have a range of 0 to 2 mg/L and which are fed by sample lines located at the end of the rapid mix chambers.

The post-chlorination injectors are located in the crawl space below the chlorine building. The solution is piped to the clearwells via PVC pipes (75 mm diameter to Module 1 and 100 mm diameter to Module 2) after passing through 50 mm rotameters. The post-chlorine diffusers are located just past the weirs at the entrance to the clearwells.

Post-chlorine analyzers which are fed by sample lines in the clearwells, are located in the Chlorine Building. As well, a final chorine analyzer which monitors the finished water discharged to the distribution system is located int the High Lift Station.

AMMONIA

Anhydrous ammonia, also supplied by Stanchem is stored in a 5,000 kg tank located at the east end of the filter building. There are two Wallace and Tiernan ammoniators which hold capacities of 50 kg/day during the study period for this report. In October 1987, ammoniator no. 1 was replaced with a 136 kg/d at capacity Wallace and Tiernan series 60-225 ammoniator, and the Module 2 unit is scheduled for replacement in 1988. This replacement was necessary because at maximum flows, the capacity of the old ammoniators was barely sufficient to dose at the required rate and at times it was not possible to convert all of the free chlorine residual to a combined residual.

The ammonia application points are in the filtered water conduits. The diffusers are directional and can be pointed upstream or downstream depending on whether SO_2 is being used. This allows for some flexibility in the length of contact time available for each chemical before the next chemical is added.

SULPHUR DIOXIDE

Sulphur dioxide for dichlorination, supplied by Stanchem, is stored in two 0.9-tone cylinders in the chorine building. There are two Wallace and Tiernan evaporators (model A-785), each with a capacity of 1,360 kg/day, and two Wallace and Tiernan sulphonators also with 1,360 kg/day capacities. The SO_2 gas injectors are located in the crawl space below the chlorine building. The solution is then piped to the filtered waste conduits via PVC pipe (100 mm for Module 2, 75 mm for Module 1).

The SO_2 is diffused into the filtered water just before it leaves the filter building.

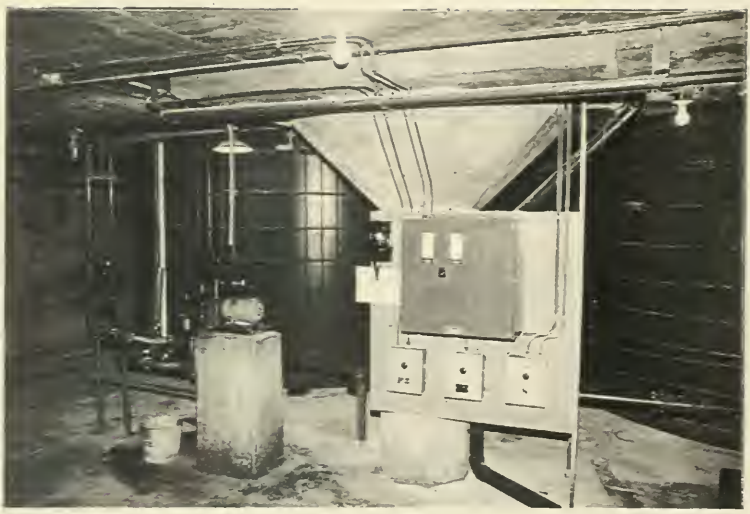
Dosage Control

The dosage control for the application of pre-chlorine is a compound loop system. The primary control is the raw water flow as measured by the Venturi meters. The secondary control which fine-tunes the chlorine dose is a chorine residual reading which is taken approximately 10 minutes after the chlorine is applied. On-line chlorine analyzers monitor the residual and automatic controls adjust the chorine dose to maintain the residual at a predetermined level. The desired residual at this first analyzer is approximately 1.0 mg/L in winter and 1.2 mg/L in summer. The dose to maintain the residual is generally 1.5 to 3 mg/L.

The selection of doses for post-chlorine and sulphur dioxide is a manual process based on operator experience. The operators monitor the readings of the five chlorine analyzers and adjust the dose as necessary.

Ammonia is added to the water at a fixed dosage based on the experience of the operators. The monthly mean dose for 1984 to 1986 was 0.21 mg/L.

C.4(b) Coagulant



ALUMINUM SULPHATE STORAGE TANKS
Dosing Pump and Flow Control Panel

Liquid aluminum sulphate ($Al_2(SO_4)_3.14H_2O$) in a 48.5% concentration is used for coagulation. It is supplied by General Chemical and is stored in two 50 m^3 polypropylene-lined wood stave storage tanks, one for each module, located on the basement level of the pretreatment chemical building. Alum is applied after pre-chlorination at the inlet to the rapid mixers by two 0.7 KW dosing pumps. The capacity of these pumps at maximum pressure is 183.5 IGPH (834L/hr or 13.9L/min.). However, the maximum reading on the Wallace and Tiernan rotameters which measure the alum flow is 1.9 IGPM (8.6L/min.). The alum injection point is in the rapid mix chamber close to the first mixing unit.

The alum dose applied is based on the experience of the plant operators; jar tests are not performed. Generally, with raw water turbidity of approximately 2 NTU, alum is added at a dose of 3 mg/L as dry aluminum sulphate. When turbidity goes up to 5 or 6 NTU, the alum dose is increased to approximately 5 mg/L as dry alum. The flow measurement, which the alum addition is based on, is the raw water flow from the Venturi meters. Section E.2 contains graphs of raw water turbidity versus alum dose for April, July and December, 1984 to 1986.

HYDROFLUOSILIC ACID STORAGE TANK

Hydrofluosilic acid (H_2SiF6 in a 25% F concentration) is stored in a 45 m^3 tank outside the Fluoride Building and is transferred to a 2.3 m^3 day tank inside the building using compressed air piped from the filter building. The acid is supplied by Min-Chem Canada Ltd. There are three metering pumps, each with a 150 L/hour capability. Two pumps are used at a time with the third on standby. The fluoride is pumped to the injection points at the entrance of the clearwells via a 75 mm diameter pipe to Module 2 and a 50 mm pipe to Module 1. The rate of H_2SiF6 addition is controlled by an electric signal of the Total High Lift Discharge Flow sent to the dosing pumps. The desired fluoride residual as measured by the laboratory is 1.0 mg/L.

C.5 Sampling

The raw water used by the laboratory for their analysis comes from the water plant via a 12 mm diameter PVC sample line. The specifics of this line are:

Length:	600-700 m
Flow:	4.6 L/min.
Velocity:	0.6 m/s
Time of Travel:	16 to 20 minutes

Water flows through this line continuously.

The laboratory staff take finished water samples for analysis from a distribution system water main through a tap in the laboratory building. The tap is kept open so that water is running at all times. All other samples are collected by plant or laboratory personnel at the source. Details of the sampling program are contained in Section D.6.

C.6 Process Automation

The flow of water through the plant is controlled and monitored by a control system which consists of 30 loops to balance flow conditions throughout the process. The chemical feed rates, including alum, pre and post-chlorine, ammonia, sulphur dioxide and fluoride, are controlled by the filtered, raw and total discharge flows. Electric and variable vacuum signals transfer the flow information to control the dosing rate of these chemicals.

A computerized process monitoring and flow control system is being installed in the plant with the design and installation being conducted by Regional staff. At the time of the writing of this report some of the computerized components were in place but none were operational.

C.7 Standby

The Hamilton-Wentworth water plant has no emergency power for operation in the event of a power failure. Enough standby power is available to close valves and a dewatering pump in the High lift station can prevent the basements of the buildings from flooding. Otherwise, no water can be treated or pumped during a power interruption.

HAMILTON-WENTWORTH WATER TREATMENT PLANT

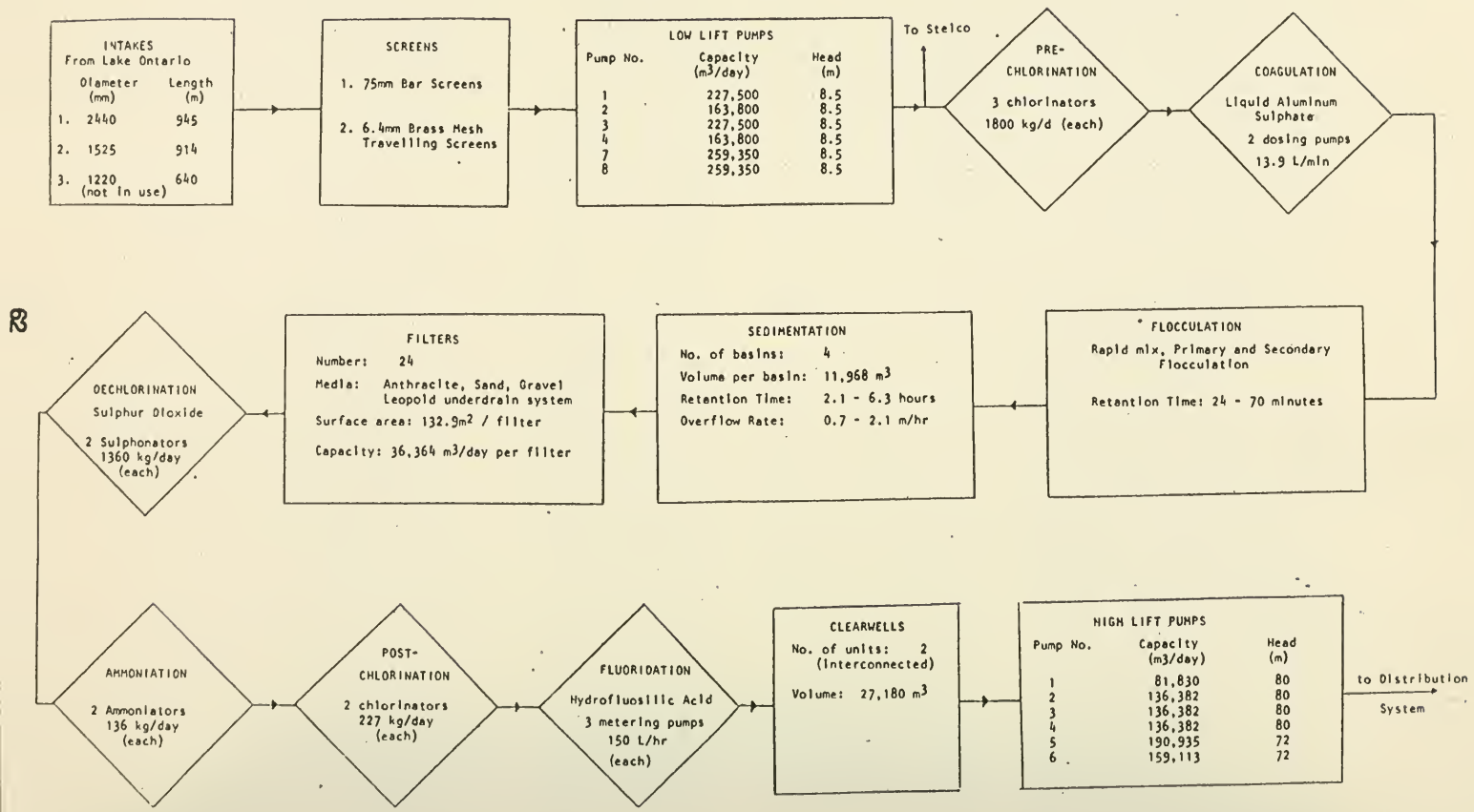


FIGURE 7

Detailed Process Schematic

SECTION D

PLANT OPERATION

D. PLANT OPERATION

D.1. General Description

The Regional Municipality of Hamilton-Wentworth Water Treatment Plant is a conventional facility utilizing coagulation, sedimentation and filtration. It is a large plant, treating an average of approximately 300,000 m^3/day and serving a population of 385,000. From the treatment plant water is pumped to the distribution system which includes seven reservoirs, eleven booster stations and ten pressure districts.

To save on hydro costs, the plant operates only at night Monday to Friday and 24 hours per day from Friday night to Monday morning. By avoiding the peak demand hours for electricity, the plant has reduced its electricity cost substantially; the estimated savings are approximately $200,000 per year.

There has been a water supply facility on the site since 1859. The significant expansions include the addition of the east filter building wing in the late 1950's and some major renovations in 1973-74. These involved new chlorination facilities and the addition of clearwell #2 and the flocculation basins. The chlorination equipment was relocated again in 1984. The filters were also renovated in 1984-85; new underdrain systems were installed and the filter media was replaced.

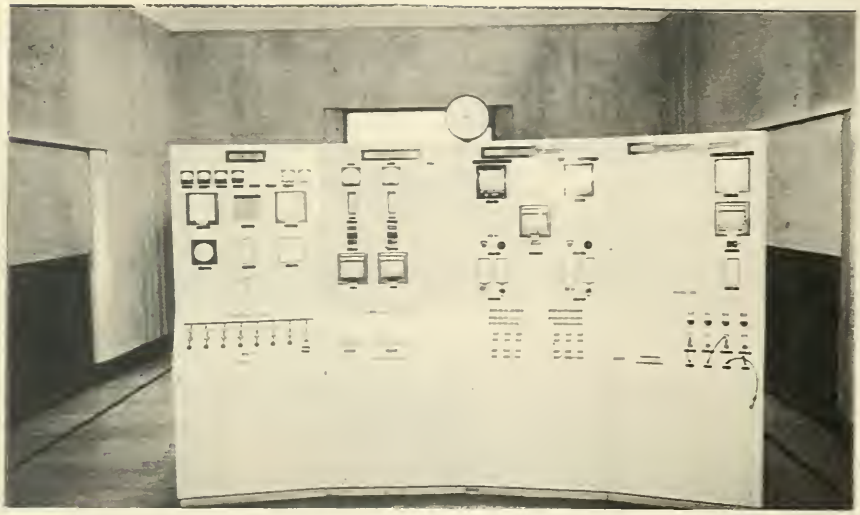
A pumpage rate is set at the beginning of each month and this rate is not changed unless there is an emergency or the reservoir water levels drop more than 20% per day. This pumping rate is based on a combination of High Lift pumps and the Low Lift pumps are set to supply enough water for the finished water flow for Stelco's requirement and for backwash water.

The filters are operated at a rate of approximately 27,000 m^3/d (6 MIGD) which is 25% below their rated capacity. To determine the number of filters to use at a time, the operator divides the set pumping rate by this filter rate.

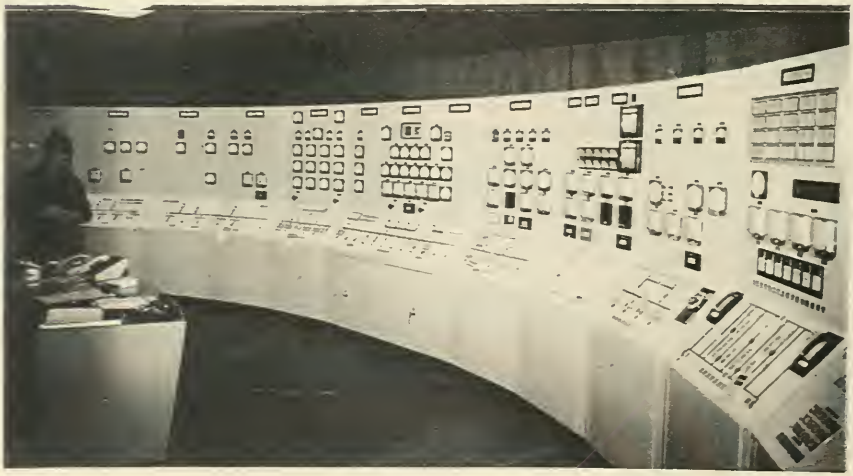
The water plant personnel includes the Superintendent and five teams of operating staff. Each team consists of a shift foreman, two operators (Class 1), and one assistant operator. Of the operators, one is in charge of the High Lift station and distribution system and the other works in the Filter Building and oversees the treatment of the water. The teams rotate on twelve hour shifts an there is operational staff on duty at all times, even when the plant is not running during weekdays. Maintenance duties are looked after by the Maintenance Department; there are maintenance staff and janitorial staff in the water plant during regular daytime hours Monday to Friday.

The maintenance and calibration of all instruments is handled by Maintenance Department personnel. Operating staff do not adjust any of the monitoring or control equipment, including on-line turbidimeters and analyzers. On-line instruments and analyzers are calibrated twice weekly.

D.2 Flow Control



CENTRAL FILTER BUILDING CONTROL PANEL



HIGH LIFT STATION CENTRAL CONSOLE

The plant is equipped with an automatic flow control system which monitors the level of water in the clearwells, the flow through the filters and the water level in the settled water conduit. It uses these measurements to control flow through the plant. There are 30 Control System Loops with the following designations:

Loop Number	Control System
1-24	Local filter rate control system
25	Clearwell Control
26	Wash water level control
27	Wash water flow control
28	Total filter flow
29 and 30	Raw water flow control

The precise filter rate is based on the clearwell level. A pneumatic signal of the level is sent from the clearwell to the Manual/Automatic Master Rate Setter in the Central Filter Control Panel which is manually set at the desired flow rate. A pneumatic signal is in turn sent to the Filter Flow Rate Controller. An additional controller, a Ramp Generator, allows for a gradual increase in the filter rate setting on start-up of a clean filter.

To control raw water flow, the total filter flow is transmitted via pneumatic and electrical signals to the Master Rate Setter. It sends an electrical signal to the Raw Water Flow Rate Controller which adjusts the position of the main butterfly valves located at the beginning of the treatment modules (beside the venturi meters). An electrical signal of the water level in the settled water conduit provides a secondary adjustment to the butterfly valve movement.

D.3 Disinfection Practices

The raw water is chlorinated for disinfection prior to rapid mixing. This pre-chlorine is added at a dose that will maintain a free chlorine residual throughout the treatment process. Following filtration, ammonia is added to the water to change the form of the chlorine from free to combined. No post-chlorination is usually required.

The pre-chlorine dose is generally 1.5 to 3.0 mg/L and this results in a filtered water free chlorine residual of approximately 0.8 mg/L. To change this to combined chlorine, a dose of approximately 0.2 mg/l ammonia was applied (until 1987). The ammonia dose has been increased to 0.3 mg/L with the installation of new ammoniators.

Post-chlorination is sometimes required for the first one or two hours after start-up of the plant. This is due to the fact that some water is held in the basins and filters during the day when the plant is not operating. The chlorine residual in this water depends on the amount of water used by Stelco during the day. Stelco draws water from the flocculation and sedimentation tanks and this water is replaced with more pre-chlorinated raw water from the Low Lift Station.

If the chlorine residual in the filter effluent is too high, the water can be de-chlorinated with sulphur dioxide. This is not usually required. On the few occasions it has been used (during taste and odour events), the dose has been less than 0.5 mg/L.

The following is a list of application points and average doses for the disinfection chemicals:

Chemical	Location	Average Dose (Mean of Monthly Means, 1984-1986)
Pre-chlorine	in raw water inlet pipe	1.8 mg/L
Post-chlorine	at inlet to clearwells	0.08 mg/L
Ammonia	in filtered water conduit	0.21 mg/L
Sulphur Dioxide	in filtered water conduit (before ammoniation)	n/a

D.4 Operation of Specific Components

D.4(a) Intakes

There are three intake pipes, however, only two are in use at the present time. The older intake (1525 mm diameter) was constructed in 1927. The 2440 mm diameter intake was designed by Proctor and Redfern and was constructed in 1967. The crib on this intake is a concrete and fibreglass structure specifically designed to protect against frazil ice. Proctor and Redfern received an award for their design of this crib.

The plant does not have the facilities to completely backflush the intake pipes. Each weekday morning, when the Low Lift pumps are turned off, the water level in the wet well rises approximately 2 m. This level then subsides which produces some back flow through the intakes, however, the volume of water is much less than that contained in the intake pipes.

D.4(b) Screening

The raw water flows through two sets of screens before reaching the Low Lift pump well. The bar screens with an operating size of 75 mm prevent large debris from entering the pumping station.

The bar screens are cleaned when necessary, but there is rarely any buildup of material on the screens. The second set of three screens (travelling) prevent material larger than 6.4 mm from entering the station. The travelling screens are cleaned by two jet pumps and the waste water is collected in a well and then discharged to Red Hill Creek. The debris collected on the screens is mostly fish.

The cleaning system is on a timer which initiates a six minute cleaning cycle once per hour. The screens are equipped with a differential pressure monitoring system with the pressure recorder located in the High Lift Station. However, when the cleaning of the screens was initiated by the pressure differential (headloss of 0.6 m), the screens were being damaged. There is less damage to the screens with the timed cleaning system. Manual initiation of the cleaning cycle is possible from the High Lift Building or in the Low Lift Station.

There is not a regular routine for inspection of the screens. Generally, they are examined when there is a problem with their operation.

D.4(c) Low Lift Pumping

Six Low Lift pumps take water from the lake and dump it to the main treatment plant which is approximately 550 m away across the Queen Elizabeth Highway. The operator selects the number of Low Lift pumps to use based on a pre-set High Lift pumping rate. The Low Lift pumps must accommodate the High Lift flow, plus the flow to the Stelco pumping station and the volume of water required for backwashes.

During the day, when the water plant is not operating, Stelco draws water out of the flocculation and sedimentation tanks. To refill the basins, the daytime operator periodically starts one Low Lift pump.

D.4(d) Rapid Mixing and Flocculation

For several years prior to late 1986, the rapid mixers were not used. Alum was injected into the raw water by the use of diffusing rings. In October, 1986, the rapid mixers were put back into service because the plant personnel suspected that the alum was not being well mixed into the water prior to flocculation. They found the settled water turbidity did improve with the rapid mixers in use. The injection points for alum have also been moved closer to the first rapid mixer blades to improve the coagulation process.

No jar tests are performed to determine the alum dosage. The minimum alum dose is 3 mg/L as dry aluminum sulphate. With raw water turbidity levels up to 10 NTU, the initial alum dose in mg/L is approximately 80% of the turbidity measurement (.i.e. turbidity of 8 NTU, initial alum dose is approximately 6.5 mg/L). The operator then "feathers" the dose back to optimize the process and maintain the treated water turbidity at as low a level as possible. When the raw water turbidity rises above 10 NTU, the operator selects an initial alum dose based on their historical experience.

The rapid mix and flocculation tanks are emptied, cleaned and inspected every 3 to 4 months when the sedimentation tanks are cleaned.

D.4(e) Sedimentation

The sedimentation tanks are cleaned and inspected every 3 to 4 months when 3 to 5 cm of sludge has accumulated. Only one basin is cleaned at a time, leaving 3 in operation. Approximately 4 m of settled water is pumped from the top of the full tank to Red Hill Creek. The remaining water and sludge is discharged to a sewer which leads directly to the Woodward Avenue Sewage Treatment Plant next door to the water plant. High pressure hoses are used to wash the sludge into the sewer.

D.4(f) Filters

Each filter is operated at a rate of approximately 27000 m^3/d (6 MIGD). The operator determines the number of filters needed in service by dividing the pre-set High Lift flow by this filter rate. The exact filter rate is determined by the Automatic flow control system. At the start-up each weekday evening or when a clean filter is put back into service, the full rate is achieved approximately 1.5 to 2 minutes after being turned on. Because the plant is usually operating at less than capacity, filters are not generally put back into use immediately following a backwash.

Backwash

FILTER GALLERY

Gauge on Left Indicates Backwash Water Rise Rate

Gauge on Right Indicates Level in Backwash Water Storage Tank

A backwash filter is initiated when one of the following conditions is reached:

1. The filter has been in use for 72 hours.
2. The filter effluent turbidity reaches 0.4 NTU.

When the headloss through the filter reaches 7.5 feet (2.3 meters) as indicated by the gauge on the filter control table, the operator checks the filter effluent turbidity. This is done by collecting a sample from the discharge pipe and measuring the turbidity in the plant laboratory. If the turbidity is less than 0.4 NTU, the filter is kept in operation until the effluent turbidity reaches that level or until the filter has been in operation for 72 hours, whichever occurs first. A backwash is then initiated.

The following is the procedure used to backwash a filter. The operator controls the backwash from the filter table.

1. Shut influent gate and allow water level to go down to the top of the troughs.
2. Shut filter off.
3. Open waste valve to clear water out of the troughs.
4. Turn surface wash on and start backwashing. Bring backwash water rise rate to 12 inches/minute (18 m/hr.)
5. When backwash water tank depth descends to 11 feet (3.4 m), increase backwash water rise rate to 25 inches/min. (42 m/hr.).
6. When backwash water tank depth reaches 5 feet (1.5 m) observe colour of wash water. If it looks clean, terminate the wash. If necessary, continue the wash unit the tank level reaches 4 feet (1.2 m).
7. To terminate backwash shut off surface wash and backwash, and close waste valves.

8. Open influent valve and allow to fill.

9. Turn filter on if required.

Only one filter is backwashed at a time. With two backwash pumps being used, up to four backwashes can be completed per hour. One backwash pumps starts when a backwash is initiated and a second pump starts when the wash water storage tank is drawn down to 3.4 m.

D.4(g) Clearwells

The clearwells are cleaned and inspected every ten years, or more often if necessary. The last cleaning was in 1984 when a combination of construction on the site and a heavy rainfall caused flooding and infiltration into the clearwells.

D.5 Chemicals

D.5(a) Chlorine

Chlorine is dosed at the pretreatment stage so as to maintain a residual of approximately 1.0 to 1.2 mg/L after approximately 10 minutes contact time (at the pre-chlorine analyzer). Generally a lower residual is maintained in the winter. The desired filtered water chlorine residual is approximately 0.8 mg/L. The operators monitor both the pre-chlorine residual and the finished water residual and adjust the pre-chlorine dose as necessary.

Post-chlorination is usually only used if the chlorine residual of the filtered water is low at the start-up of the plant. This often occurs because water is held in the basins during daytime non-operating hours. The level of the chlorine residual is partly dependent on the amount of water Stelco draws out of the flocculation and sedimentation basins, since this water is replaced with pre-chlorinated raw water.

The calculation for post-chlorine dose is:

$$\text{Post } Cl_2 \text{ dose} = \frac{\text{Wt. of } Cl_2 \text{ used}}{\text{volume of filtered water}}$$

The volume of filtered water is calculated by the following equation:

Filtered water volume = Total High Lift Flow
+ Backwash water used
+/- Net volume change in clearwells

D.5(b) Alum

The plant does not have a set policy on the dose of alum as related to the raw water turbidity; the operators base the dose on their experience and the turbidity of the finished water. To verify the alum dose the metering pumps are calibrated twice per shift or when the dosing rate is changed by timing how long it takes to empty a graduated cylinder. The calculation for average alum dose each day is:

$$\text{Alum dose (as dry alum)} = \frac{\text{Litres of alum used x 0.65 kg/L}}{\text{Low lift pumpage - Stelco pumpage}}$$

D.5(c) Sulphur Dioxide

Sulphur dioxide is used for dechlorination, but it is very rarely needed. The average daily SO_2 dose is based on the filter water flow:

$$SO_2 \text{dose} = \frac{\text{Wt. of } SO_2 \text{ used}}{\text{Volume of filtered water}}$$

D.5(d) Ammonia

Ammonia is added after filtration to change the free chlorine residual to monochloramine. The dosage is set on a fixed rate based on the experience of the operators. With a finished chlorine residual of 0.8 mg/L, the ammonia dose is approximately 0.2 mg/L.

The daily ammonia dose calculation is:

NH_3 dose: $\frac{\text{Wt. of ammonia used}}{\text{Volume of filtered water}}$

D.5(e) Fluoride

Fluoride is dosed so as to maintain a residual of approximately 1.0 mg/L. The concentration of the hydrofluosilic acid solution is included in the daily dose calculation.

F-dose: $\frac{\text{Wt. of } H_2SiF_6 \text{ used x 0.25 (concentration)}}{\text{Volume of filtered water}}$

D.6 Sampling & Data Collection

The following table show the in-plant sampling and testing:

IN-PLANT SAMPLING						
Collected By	Analyzed By	Sample Location	Analysis	Frequency	Method	Where Recorded
plant staff	plant staff	high lift discharge	total Cl2	every 2 hours	DPD ferrous titration	filter building log
plant staff	plant staff	clearwell	turbidity	every 2 hours	Hach 18900 ratio turbidimeter (plant)	filter building log
lab. tech.	lab. tech.	*5 chlorine analyzers	total Cl2	twice per shift	DPD ferrous titration	daily inspection log
plant staff	lab. tech.	high lift discharge	turbidity	every 2 hours	Hach 18900 ratio turbidimeter (lab)	separate log

Note: 5 chlorine analyzers - 2 in tunnels at north end of plant for pre-chlorine
2 in chlorine building for post-chlorine
1 in High Lift for final residual check

The laboratory is located at the Woodward Avenue Sewage Treatment Plant next to the Water Treatment Plant. Both raw and treated water is analyzed at the laboratory. As well, laboratory personnel visit the water plant during plant operation to calibrate instruments and collect samples.

The raw water used for the analysis in the laboratory is obtained from a sample line which extends several hundred meters from the entrance to the treatment facility to the laboratory building. On this water the following analyses are performed:

Raw Water Analysis	Frequency	Method
pH	twice per day	electrode
Ammonia	hourly	Nesslerization method with distillation
Alkalinity	twice per day	Titration with sulphuric acid
Total Hardness	twice per day	EDTA Titration Method
Chloride	twice per day	Mercuric Nitrate Titration Method
Fluoride	twice per day	SPADNS Method
Turbidity	hourly	Turbidimeter
Total Coliform Bacteria	three times per day	Membrane Filter
Fecal Coliforms	three times per day	Membrane Filter
Algae	not done during this period of study	Identification & Counting

(All methods are based on Standard Methods for the Examination of Water and Wastewater)

The finished water used for the analyses is taken from the distribution system through a tap in the laboratory building. The tap is kept open so that water is running at all times. The analyses performed on this water is as follows:

Finished Water Analysis	Frequency	Method
pH	twice per day	electrode
Ammonia	three times per day	Nesslerization method with distillation
Alkalinity	twice per day	Titration with sulphuric acid
Fluoride	twice per day	SPADNS method
Turbidity	hourly	Turbidimeter
Free chlorine	hourly	DPD ferrous
Total chlorine	hourly	Titrimetric method
Total plate count	two to six times per day	
Presence-absence test	three to seven times per day	5 day test mannitol salt agar test performed if sample becomes acidic, complete set of contamination tests performed if gas produced in P-A bottle

(All methods are based on Standard Methods for the Examination of Water and Wastewater)

A laboratory technician visits the water plant twice per operating shift. The purpose of these visits is to calibrate the five on-line chlorine analyzers in the plant. One is located in the High Lift station, two are in the chlorine building for post-chlorine monitoring and two are in the tunnels at the north end of the plant for pre-chlorine monitoring. Water samples are collected at each analyzer and taken to the filter building for chlorine analysis. The results of these tests are recorded, but are not included with the other lab data. The technician adjusts the analyzers if necessary.

Figure 8 shows the various sampling points in relation to the treatment process.

HAMILTON-WENTWORTH WATER TREATMENT PLANT

Water Quality Analyses

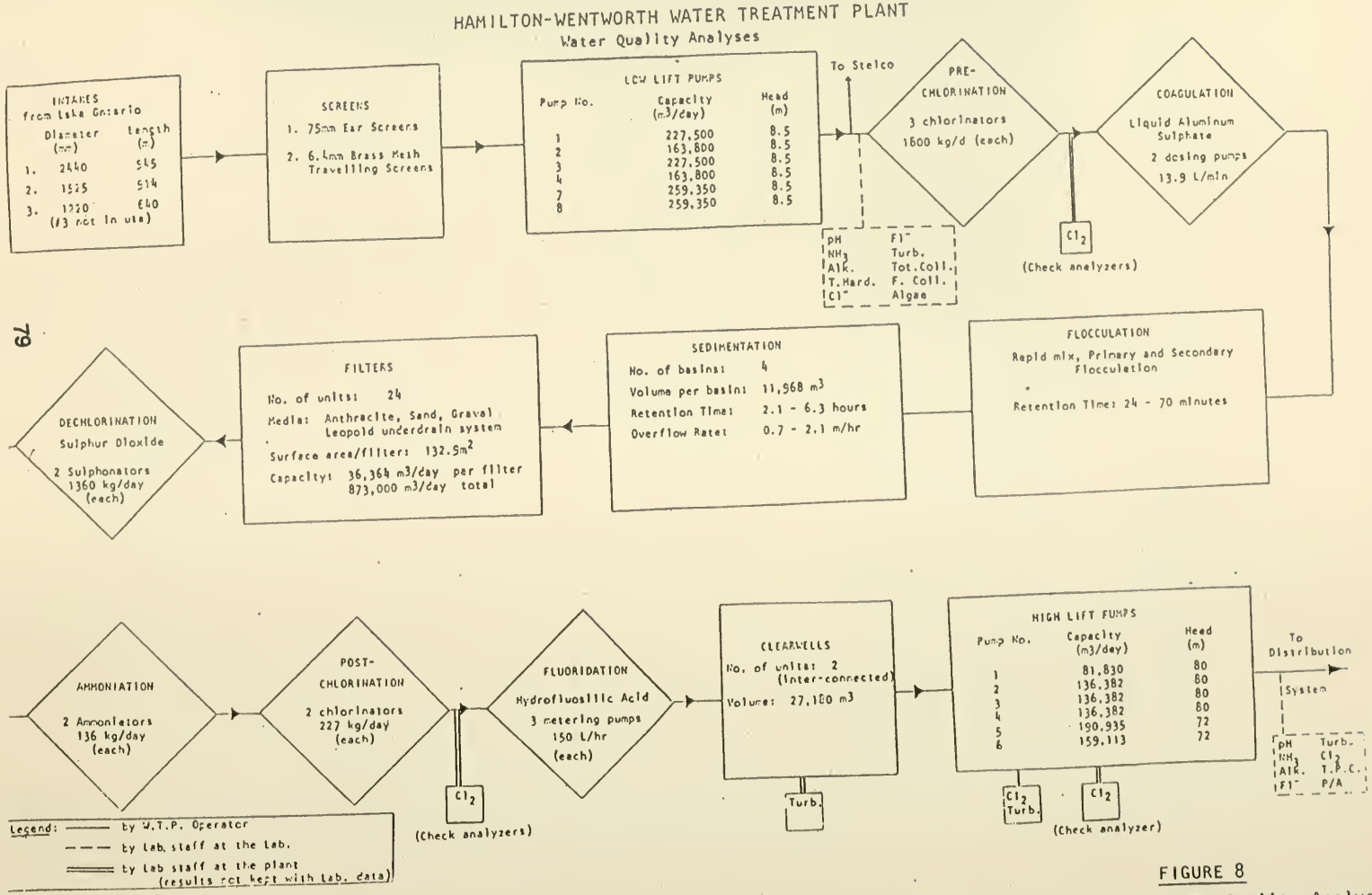


FIGURE 8

Water Quality Analyses

D.7 Process Automation

Automation of the Hamilton-Wentworth plant includes a flow control and balancing system, and a chemical dosing/feeding system. Otherwise, the treatment of the water is not automated and operator input, experience and understanding of the processes are integral to the successful operation of the plant. There is not an automatic data collection or storage system other than for flow data. A computerized process monitoring and operating system is being installed, but it is not yet in operation.

D.8 Daily Shift Duties

The operators on duty are responsible for completing three daily logs which contain the following general information:

Filter Building Log:

- filter data; headloss, length of runs, rate
- chemicals used and dosages
- finished water turbidity and chlorine residual
- total flows: raw, washwater, High Lift
- clearwell levels

Low Lift Pumping Station Log:

- low lift pumpage and rates
- raw water valve positions
- hours each pump is run

No. 1 District Pumping Station Log:

- high lift pumpage and rates
- #1 reservoir levels
- hours each pump is run-Stelco pumpage,
- maximum pumping rate and station head.

Samples of these logs are contained in Appendix C. As well, at the end of each month a summary of plant flows and chemical doses and a record of "Utilities and Materials Consumption" are produced. Examples of these reports can also be found in Appendix C.

While the plant is running, the assistant operator walks through the plant every two hours, collecting samples and checking instruments. A list of these activities follows:

- check alum flow
- check pre-chlorine analyzer for each module (note pressure)
- record raw water turbidity meter reading
- check alum dosing pumps
- twice per shift or when dosing rate is changed, calibrate the dosing pumps by timing how long it takes to empty a graduate cylinder
- in the High Lift station collect a finished water sample from the discharge line
- record weight of Hydrofluosilicic acid day tank in the Fluoride Building
- in the Chlorine Building check the gas pressure and the injector suction of the pre-chlorinators

- check post-chlorinators
- check the temperature and pressure in the evaporators and the water level in the evaporator
- collect a sample from clearwell #2
- record settled water turbidity meter reading for modules 1 and 2
- check the raw water temperature (indicator in filter building)

SECTION E

PLANT PERFORMANCE

E. PLANT PERFORMANCE

E.1 General Overview

The water treated at the Hamilton-Wentworth plant is generally of very high quality. With respect to particulate removal, the average treated water turbidity for the study period was 0.38 NTU. The bacteriological quality of the water is also good. No positive presence-absence test results were reported and no total plate count result exceeded 500 organisms/ml in the study months.

In 1986, the long time Plant Superintendent retired. Since that time, with new supervisory personnel at the plant, the interest in improving plant performance and optimizing all aspects of the process has increased. Walter Furry, the current plant Superintendent, has been working hard at improving the awareness and interest level of the staff which is one of the most important and effective optimization tools. As well, in the past two years, several studies to investigate performance improvement methods have been initiated.

Consumer complaints are handled by laboratory personnel. Most of the complaints concern water pressure rather than water quality. However, some calls regarding chlorine taste and odour are received. Records of complaints are not kept.

E.2 Particulate Removal

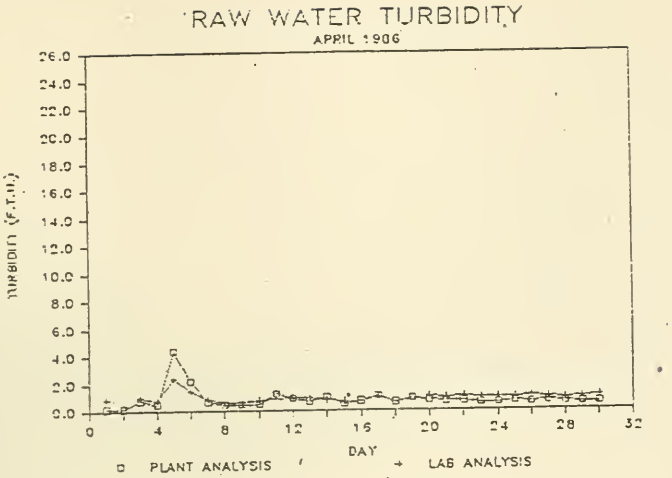
E.2(a) Raw Water Quality

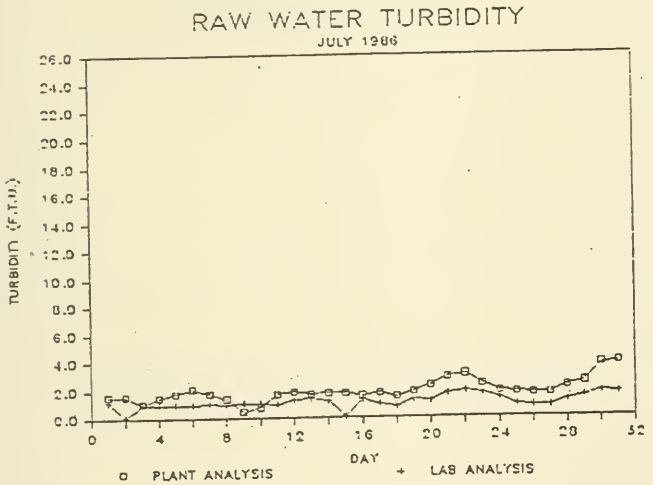
The particulate removal summary and particulate removal profiles for 1984 to 1986 are contained in Appendix A (Tables 2.0 and 2.1 respectively). These tables contain information on raw and treated water turbidity, the alum dose, raw and treated water pH and temperature of the raw water;

Table 2.0 contains monthly maximums, minimums and means, and Table 2.1 contains the daily means for the months of April, July and December.

The turbidity of the raw water is measured and reported at two locations. The laboratory staff takes turbidity readings and records them on the daily laboratory sheets. The turbidity is also measured at the water plant and a daily average is reported on the plant's monthly report. The raw water turbidity values from the two sources vary. The raw water used by the laboratory for their analyses comes from the water plant via a sample line several hundred meters in length. Although water is running through the pipe at all times, some changes in the water quality may take place within the sample line. The graphs in Figure 9 show this variance in turbidity values. This may be due to one or more of: water quality changes in the sample line, sampling at different hours, a difference in the calibration and/or operation of the turbidimeters. The difference in magnitude of the two means is usually all (less than 2 NTU), but because the values are also low, the difference is noticeable. For consistency, the comparison of turbidity made in this section will be using the plant raw turbidity data since these are the values available to the plant staff when they set the alum dose.

Figure 10 shows the monthly maximum, mean and minimum raw water turbidity readings for 1984 to 1986. The incoming turbidity is quite low with the monthly mean consistently below 7 NTU. The highest raw turbidity for the three year period was 20.7 NTU in December, 1986. (A high of 33 NTU was recorded at the laboratory in April 1985.) The operators can usually predict a rise in the turbidity by watching the weather. Storms with easterly winds off the lake generally mean higher raw water turbidities.





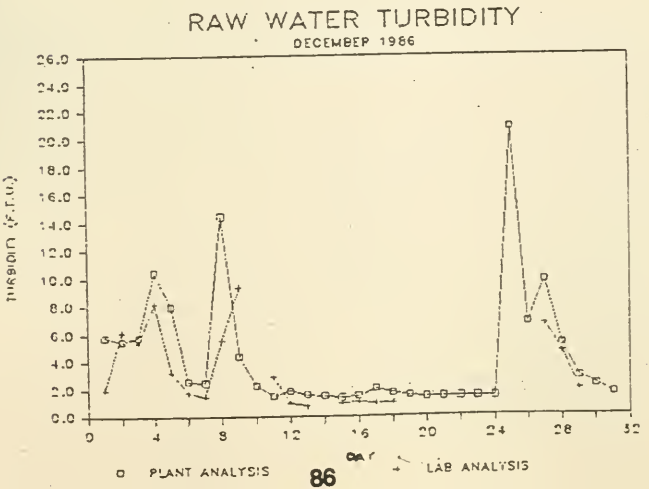
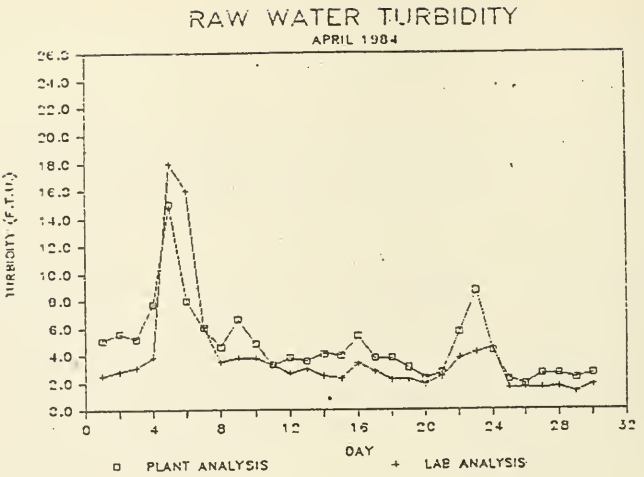
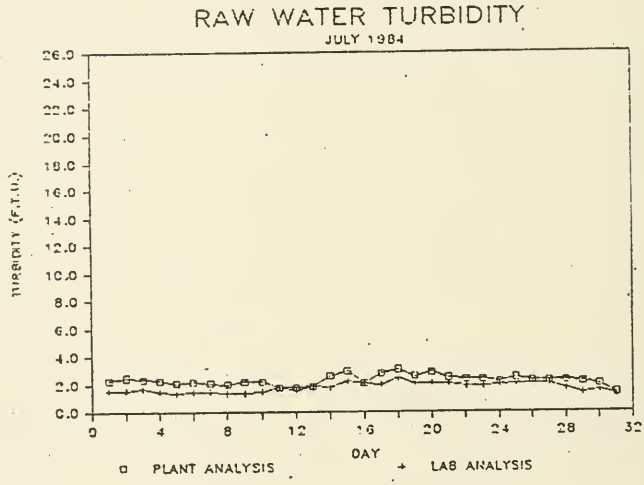


FIGURE 9
Raw Turbidity
Plant vs. Lab





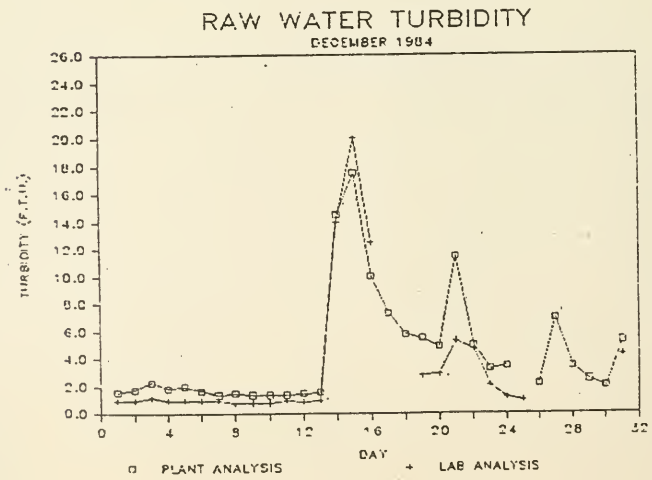
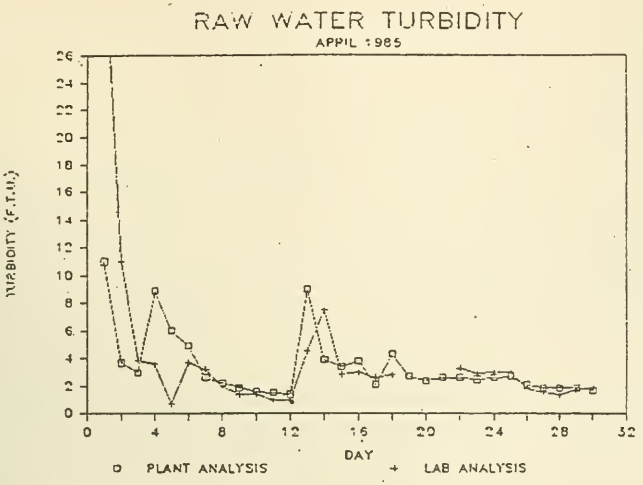
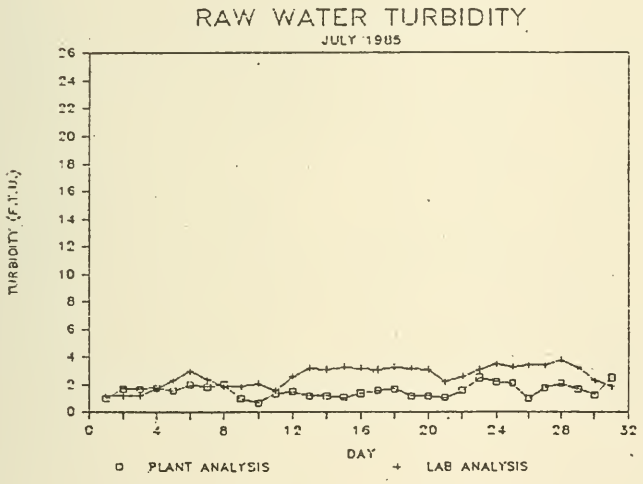


FIGURE 9 (cont'd)





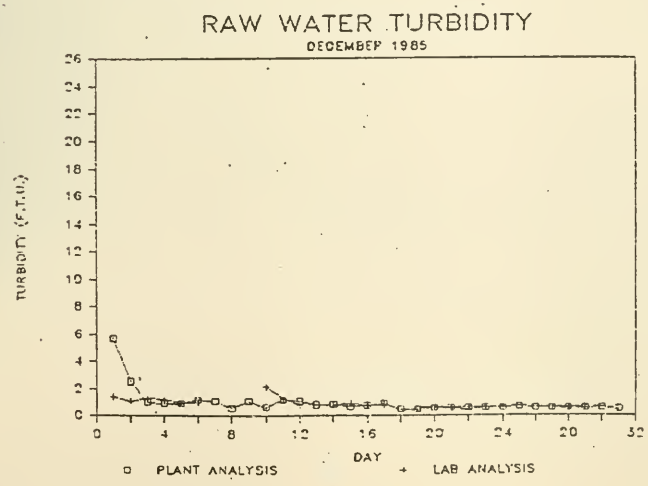


FIGURE 9 (cont'd)

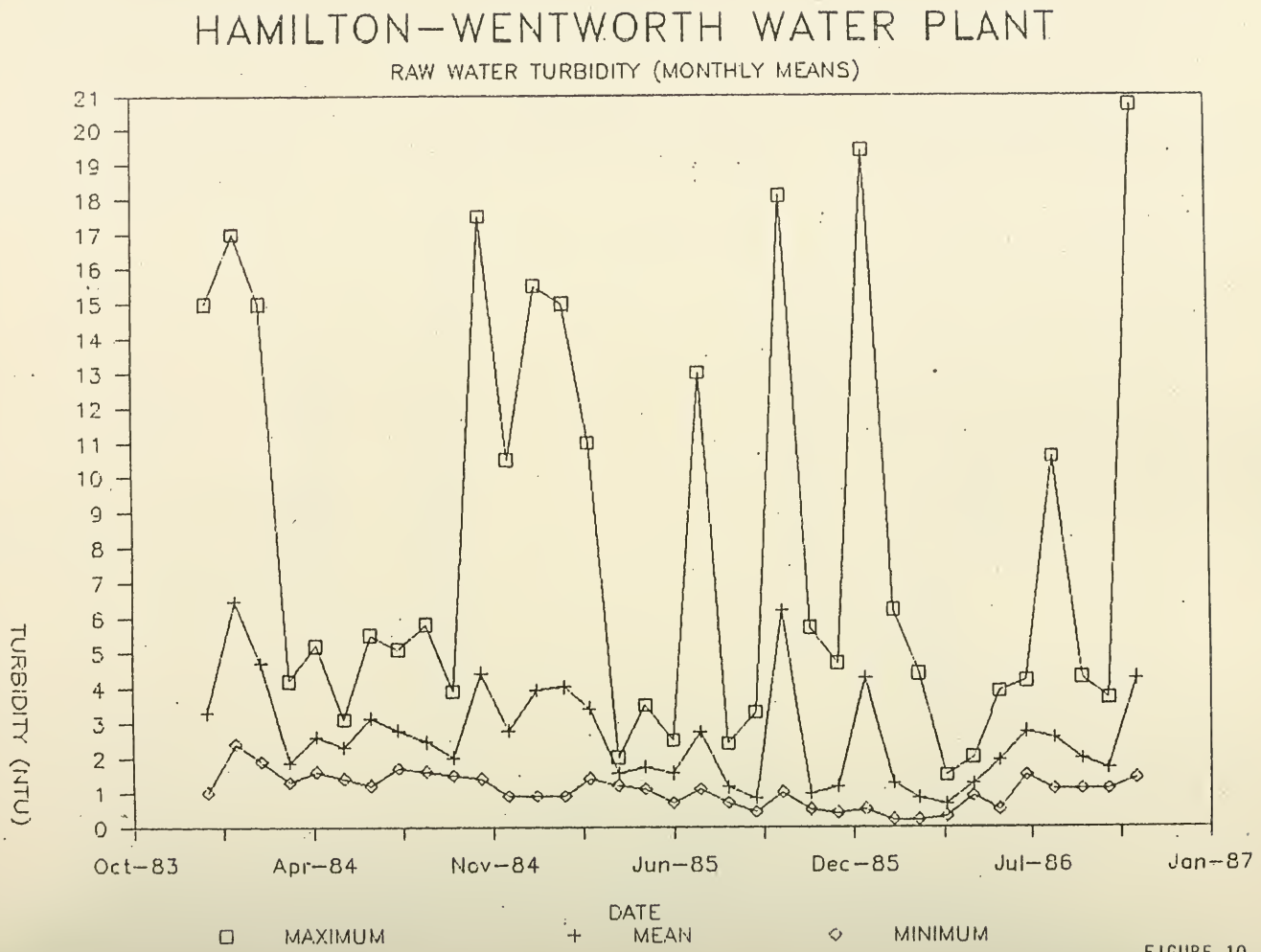


FIGURE 10

Raw Water Turbi-

E.2(b) Particulate Removal

The following table shows raw water turbidity values greater than 10 NTU for the study period, the corresponding alum dose and the resulting treated water turbidities (data are daily averages):

Date	Raw Turbidity (NTU)	Alum Dose (mg/L)	Treated Turbidity (NTU)	Flow (1000 m3/d)	Hr. of Operation	Sed. D/F Rate (m/hr)	Filter Rate (m/hr)
Thurs.Apr.5/84	15.0	10.6	0.49	252	13.5	1.72	7.52
Fri.Dec.14/84	14.5	4.3	0.26	223	13.5	1.52	7.99
Sat.Dec.15/84	17.5	7.1	0.39	404	24	1.55	8.44
Sun.Dec.16/84	10.0	6.3	0.31	372	24	1.42	7.78
Fri.Dec.21/84	11.5	4.7	0.28	227	13.5	1.54	8.13
Mon.Apr.1/85	11.0	9.1	0.90	186	13.5	1.27	8.14
Thurs.Dec.4/86	10.4	6.3	1.00	227	13.5	1.54	7.62
Mon.Dec.8/86	14.4	5.1	0.30	201	13.5	1.37	7.45
Thurs.Dec.25/86	20.7	9.2	not measured	81	13.5	0.55	6.30

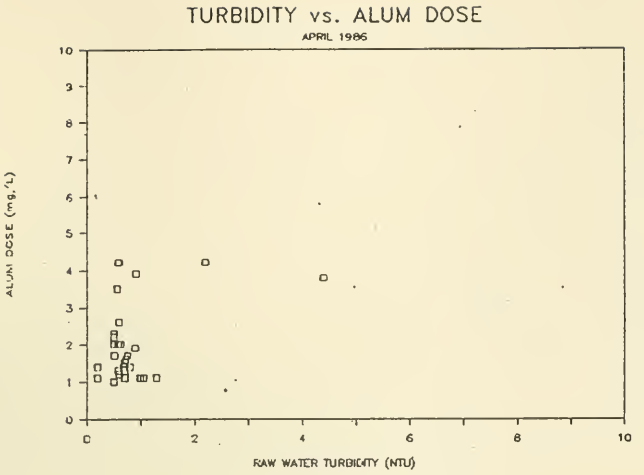
As can be seen from the above table, an occurrence of high turbidity usually lasts one to three days. These high turbidity events included a range of flow conditions from very low to above average.

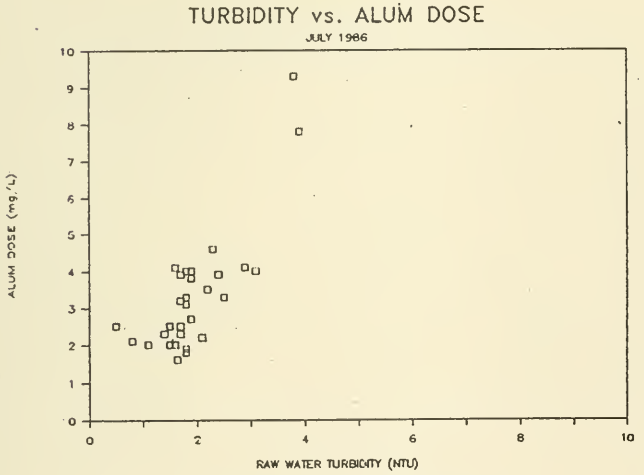
The filter rates on the occasions in 1986 were approximately two-thirds of the new filter design rate of 11.4 m/hr. The filter rates of the 1984 and 1985 events were all below the former filter rate of 8.6 m/hr. The sedimentation overflow rates ranged from 0.6 to 1.7 m/hr.

Unfortunately, there is not a record of settled water turbidity or filter effluent turbidity. The treated water turbidity on all of these occasions met the Provincial Water Quality Objective of 1.0 NTU. However, two readings were at or near the criteria.

The mean treated water turbidity for the study period was 0.38 NTU and the range of values was 0.13 to 1.27 NTU. The PWQO of 1 NTU was exceeded only one time in the 9 study months.

The alum dose versus the turbidity was not consistent; this is illustrated by the graphs in Figure 11. The operators base their selection of the alum dose on the turbidity reading and on their experience. In the past two or three years the use of alum has become more conservative, according to Walter Furry. The operators now try to achieve the best possible finished water using the minimum amount of alum. It should be noted that the alum dose calculation is based on the flow of raw water as measured by the venturi meters. Since the accuracy of these flow measurements is questionable, the reported alum dose may also be inaccurate.





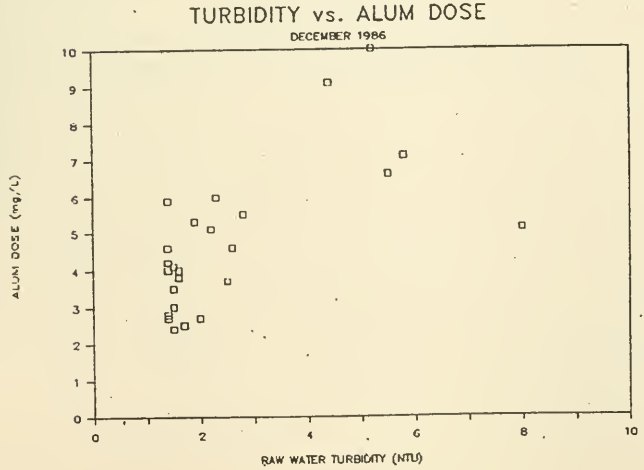
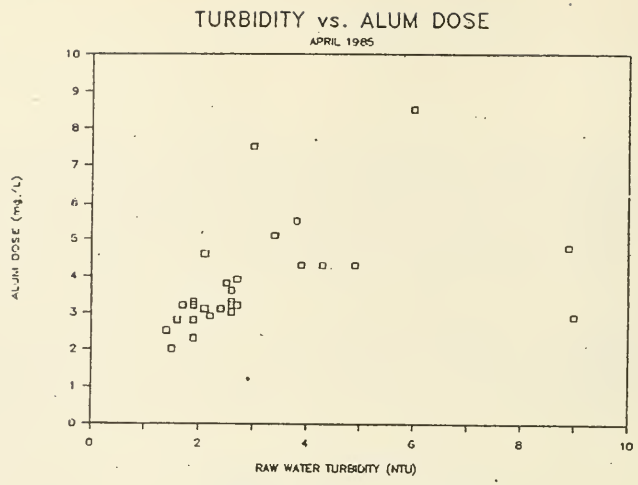
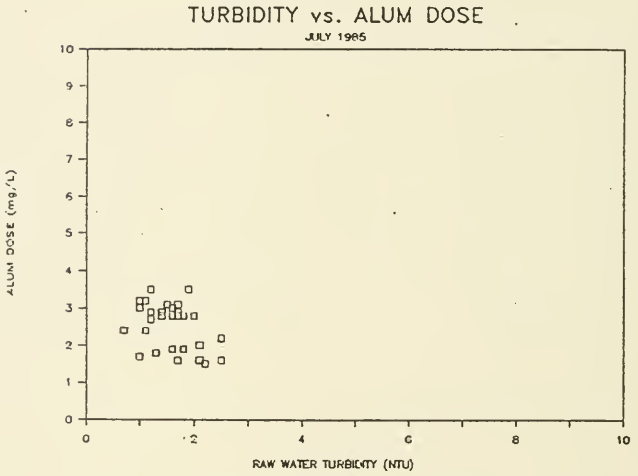


FIGURE 11

Turbidity vs. Alum





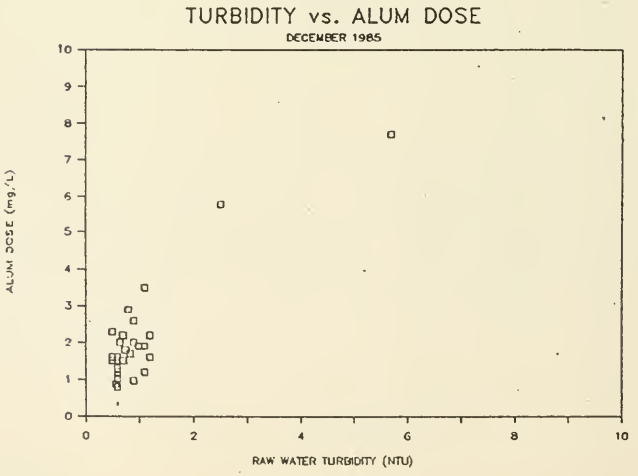
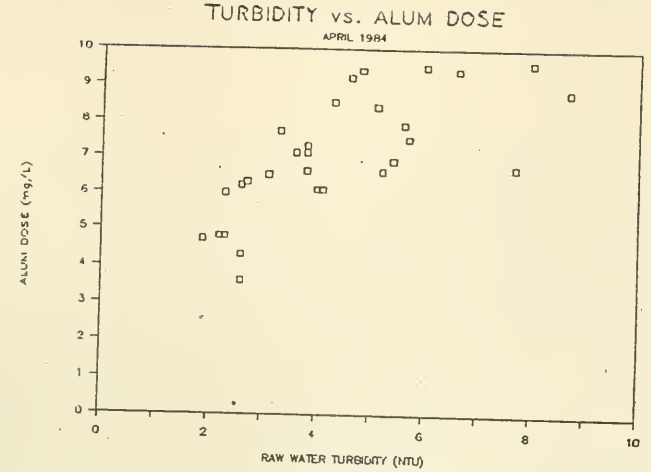
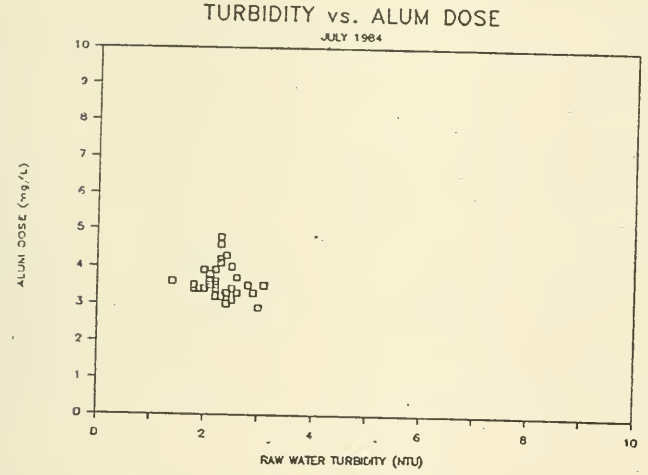


FIGURE 11 (cont'd)





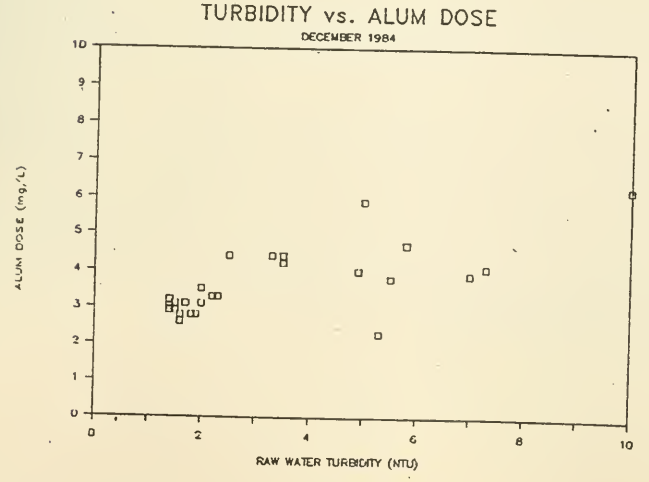


FIGURE 11 (cont'

E.2(c) Strategies for Optimum Particulate Removal

Most of the possible strategies to improve particulate removal at the plant have been acted upon by the Plant Supervisor since this study began. During the period of study for this report (1984 to 1986) the treated water did generally meet the objectives for particulate removal. However, since some changes in personnel at the plant in 1986 and 1987, the concern for optimizing performance has increased. Alternative strategies which have or could be investigated are:

1) Installation of a streaming current detector (S.C.D.) to optimize the alum dosage. The S.C.D. is an on-line, charge measuring instrument which enables the plant operator to know the optimum coagulant dosage at all times. The instrument can be installed to provide a signal to the dosing pumps to automatically control the rate of the chemical feed. An S.C.D. would provide immediate response to changes in raw water turbidity and would prevent over and under-dosing of alum. The accuracy of the doses calculated at the present time is not known (due to questionable flow measurement). The S.C.D. would determine the optimum amount of alum to add without reliance on the measurement of the flow.

   A test with streaming current detectors on loan from the manufacturers was conducted in January, 1988. The test was not long enough to provide conclusive results.

2) Investigation of other Coagulants or Flocculant Aids:

   Tests using a polyelectrolyte flocculant aid were carried out in 1987 using a pilot scale facility at the water plant. The tests were discontinued when sever mud-balling of the filters occurred.

A full-scale plant test was conducted in January - February, 1988 to evaluate the use of Sternson polyaluminum chlorine (PAC) as a prime coagulant. It was found that a dose of 0.5 mg/L PAC compared favourably with an alum dose of 3 mg/L. The tests were run using PAC in one module and alum in the other. The particulate removal results of the tests were:

	MEAN	RANGE
Raw Water - Turbidity (NTU)	1.5	0.41-8.0
- Aluminum (mg/L)	0.02	0.01-0.22

	ALUM		PAC	
	Mean	Range	Mean	Range
MIXED WATER				
-Aluminum (mg/L)	0.21	0.06-0.53	0.37	0.01-2.20
-Suspended Solids (mg/L)	3.5	0.8-18	5.0	1.0-27
SETTLED WATER				
-Turbidity (NTU)	1.50	0.48-5.5	1.6	0.12-5.2
-Aluminum (mg/L)	0.18	0.08-0.57	0.05	0.01-0.38
-Suspended Solids (mg/L)	2.8	1.0-0	3.6	0.4-13
FILTERED WATER				
-Turbidity (NTU)	0.37	0.10-2.0	0.39	0.11-0.70
-Aluminum (mg/L)	0.03	0.01-0.20	0.02	0.01-0.08
CLEARWELL				
-Turbidity (NTU)	0.41	0.11-2.0	0.39	0.13-2.0

NOTE: Outlying data more than two standard deviations from the mean were discarded.

Although PAC costs considerably more than alum on a volume basis, at the compared dosages PAC could be less expensive to use. However, PAC is also known to be most effective at cold water temperatures. Further investigation of PAC will be conducted in warmer weather. As well, the Plant Superintendent is planning to evaluate another prime coagulation from General Chemical in the near future.

3) Filter Operation:

Because of the part-time operation of the plant on weekdays, filters are turned off and on between backwashes. There has been some concern that this practice reduces the quality of the filter effluent. The full-scale tests in January and February, 1988 also included hourly monitoring of the filters (headloss, influent and effluent turbidity). The test included 17 weekdays when the filters were turned on and off without being cleaned. In approximately 60% of the comparisons, the turbidity of the filter effluent was higher at start-up than at shut-down. The turbidity levels were approximately equal in 30% of the comparisons and the turbidity at start-up was lower than at shut-down in 10% of the comparisons.

The magnitude of the variance in the turbidities was quite small and more extensive evaluation of the results is needed before conclusions can be drawn. These evaluations are outside of the scope of this study.

E.3. Disinfection

E.3(a) Efficiency of Disinfection Practices

The disinfection summary for 1984 to 1986 and the daily disinfection profiles for the months of April, July and December are contained in Appendix A, Tables 3.0 and 3.1.

Table 6 in Appendix A contains the results of bacteriological testing of the raw and treated water for the above months.

The raw water is chlorinated prior to the addition of alum and rapid mixing. A residual of free chlorine from this dose is maintained through flocculation, sedimentation and filtration. The minimum contact time through these units is approximately 1.6 hours. The chlorine is dosed at a rate that will allow a post filtration residual of approximately 0.8 mg/L.

Following filtration, the free chlorine residual is changed to a combined form by the addition of ammonia. The combined residual should be in the form of monochloramine if the chlorine to ammonia ratio by weight is kept at 4:1 or 5:1. Combined chlorine is less effective than free chlorine for disinfection, but it is longer lasting. In Hamilton, the initial free chlorine application followed by the retention time in the plant serves to disinfect the water. The combined chlorine residual then maintained the level of disinfection in the distribution system.

The plant is equipped with post-chlorination facilities for final adjustment of the chlorine residual if required. Sulphur dioxide is also available if de-chlorination is necessary, however, the SO_2 is rarely used.

The chlorination facilities were upgraded in 1984. At that time, the pre-chlorine application point was moved in order to increase the chlorine contact time prior to coagulation. The ammonia and sulphur dioxide application points were also adjusted to improve contact times. The ammonia diffusers, located in the filtered waste conduits after the SO_2 application points, can now be directed either upstream or downstream to provide flexibility in the time between chemical applications.

The following table shows the mean and the range of disinfection chemical doses and the final chlorine residual (monthly means) for 1984 to 1986:

	MEAN	RANGE
Pre-chlorine dose	2.1	1.0-3.9
Ammonia dose	2.1	0.03-0.80
Post-chlorine dose	0.08	0.00-1.50
Sulphur dioxide dose	0.00	0.00-0.36
Total chlorine residual (all units: mg/L)	0.79	0.54-1.14

The above chlorine residual results were taken from the water plant monthly report where only total chlorine is recorded.

Small amounts of free chlorine are sometimes detected by the laboratory in their treated water samples. The mean and range of chlorine residuals for the nine study months (laboratory data) are:

	MEAN	RANGE
Total Chlorine	0.73	0.26-1.03
Free Chlorine (units: mg/L)	0.002	0.00-0.47

The treated water is analyzed for bacteriological quality using Total Plate Count which is equivalent to Standard Plate Count and Presence-Absence tests. The Provincial Water Quality Objectives for safe water are a limit of 500 organisms per ml (based on a geometric mean of 5 or more samples) for Standard Plate Counts and no positive results within 48 hours for the Presence-Absence test. These limits were not exceeded for the months of study in Hamilton.

The following is a summary of the treated water test results showing the percentage of samples in each category:

Month (1984-1986)	No. of Samples	Percentage of Samples Analyzed					
		Total Plate Count (# organisms per ml)					Presence-Absence Test Positive Results.
		0	1-5	6-10	11-500	>500	
April	276	45	43	4	8	0	0
July	328	56	38	3	3	0	0
December	173	56	37	3	4	0	0

Once per month, samples are collected and sent to the Ministry of the Environment laboratory for Trihalomethane analysis. The results of these tests are shown in table 4 of Appendix A. Low levels of THMS have been found in the treated water, but the concentrations are much lower than the PDWO of 350 ug/L. The average concentration of total THMS found in Hamilton treated water and distribution system samples from 1984 to 1986 was 23 ug/L and the range was 2 to 51 ug/L.

E.3(b) Strategies for Optimum Disinfection

The Hamilton-Wentworth plant has an excellent disinfection record and the production of Trihalomethanes is very low. Little could be done to improve the plant performance in this regard. However, the consumer complaints of excessive chlorine taste and odour suggest that undesirable forms of combined chlorine may be forming either at the plant or in the distribution system. Very low concentrations of dichloramine or nitrogen trichloride can cause an offensive taste and odour.

To determine if this is a problem, the forms of the combined chlorine residual should be analyzed as the treated water unit leaves the plant and in distribution system samples.

If the unwanted forms of combined chlorine are being produced, the operating strategy of the plant could be changed. The chlorine applied before treatment may react with natural ammonia and organic nitrogen in the raw water to form dichloramine and nitrogen trichloride which then remain through the treatment process. To prevent this occurring, the pre-chlorine dose could be reduced, and post-chlorination could be used to increase the residual after the addition of ammonia. In this way, the formation of monochloramine would be more controlled and the chances of producing dichloramine and nitrogen chloride would be reduced.

E.4 Fluoride

The following table shows the raw water fluoride concentration, the fluoride dose and the treated water concentrations for the study months:

	Raw F-	Fluoride Dose	Treated F-
1984 April	0.19	1.07	1.04
July	0.21	0.96	0.99
December	0.21	1.06	1.06
1984 April	0.21	1.02	1.04
July	0.18	0.94	1.02
December	0.19	0.99	0.99
1986 April	0.14	0.87	0.86
July	0.18	0.85	1.00
December	0.18	0.95	0.95
(all units: mg/L)			

In all cases, the fluoride concentration in the treated water was less than the sum of the raw concentration and the dose. This appears to be a common situation at most water plants. A possible explanation is that some of the fluoride is being complexed with other elements in the water and is not being detected by the conventional analytical methods.

E.5 Washwater

The average washwater used in 1986 was approximately 1% of the total plant flow. Increasing the maximum filter run to 72 hours in February 1986 reduced the consumption of washwater and did not cause a decrease in filtered water quality. The change was a successful optimization measure.

SECTION F

RECOMMENDATIONS

F. RECOMMENDATIONS

1. The accuracy of flow measurements throughout the plant should be assessed and the measuring devices should be calibrated. The rates of chemical application are based on flow signals from these devices and since the accuracy of the flow data is not known, the accuracy of the chemical dosage data is also in question.

2. Guidelines for the rate of coagulant addition with respect to raw water turbidity should be set. The relationship between alum and turbidity need not be "hard and fast" so as to prevent adjustment by the operator, but a general operating strategy and a range of optimum doses should be determined and recorded.

3. The form of the combined chlorine residual in the treated water should be determined on a outline basis. If undesirable forms of combined chlorine are being formed, changes in the rates of pre- and post-chlorination could correct the problem.

4. The laboratory should improve their reporting system and make the data more available for review and evaluation. All of the analytical results should be recorded clearly in one location and the results of tests which take more than 24 hours should be recorded under the date the sample was taken, not on the day the test was completed. Monthly summaries should be produced.

5. A review of the routine laboratory tests should be conducted. For example, the practice of measuring the hardness of the raw water twice a day does not appear to be necessary, since this information is used rarely. Analyses such as aluminum in the raw and treated water and total kjeldahl nitrogen in the raw water could be more useful to the operating staff at the plant.

6. A study to determine if there are any changes in water quality through the raw water sample line to the laboratory should be conducted. The results of analyses on water which thus travelled though this pipe may not be reflective of the true raw water quality.

7. The policy of only allowing Maintenance Department staff to calibrate or check instruments should be reviewed, Since the operating staff use and rely on the instruments daily, it would seem appropriate for them to be able to make adjustments to the instruments and be responsible for their day to day operation.

8. Methods to reduce the condensation on the calibration cells of on-line turbidimeter should be investigated. High humidity in the plant causes this problem which may be resulting in false readings. This problem should be solved before the computerized process control system is put into use, since it will be the output from 24 on-line turbidimeters installed on the filter effluent discharge pipes.

9. Records of consumer complaints should be maintained and organized in such a way that trends would be noticeable. This could easily be achieved with a mapping system and a cross-referenced filing system.

10. The potential of streaming current detectors to optimize coagulation should be investigated further. However, if the flow metering devices in the plant are properly calibrated, there may not be a need for streaming current detectors.

11. A thorough analysis of data on filter effluent quality at start-up and shut-down should be conducted. It may be possible to improve the overall filtered water quality by running the plant continuously or by wasting the initial flow when a filter which is part way through a use cycle (not backwashed) is turned on.

APPENDIX A

TABLES

Table

TABLE 1.0

THE REGIONAL MUNICIPALITY OF HAMILTON WENTWORTH WATER TREATMENT PLANT

MONTHLY SUMMARY OF WATER FLOWS
(all units: x 1000 m3/day)

	1986			1985			1984		
	MAXIMUM DAILY FLOW	MINIMUM DAILY FLOW	AVERAGE DAILY FLOW	MAXIMUM DAILY FLOW	MINIMUM DAILY FLOW	AVERAGE DAILY FLOW	MAXIMUM DAILY FLOW	MINIMUM DAILY FLOW	AVERAGE DAILY FLOW
JANUARY									
raw	470.5	100.0	276.0	367.9	256.1	298.2	376.2	132.0	306.9
treated	439.2	100.0	260.3	346.8	241.9	281.8	351.8	121.1	291.1
FEBRUARY									
raw	469.1	185.0	277.9	380.3	284.0	315.5	393.2	265.5	343.5
treated	433.9	176.7	265.5	350.7	267.4	297.1	369.3	259.0	325.0
MARCH									
raw	450.0	172.7	282.1	470.5	175.5	299.7	482.9	203.2	306.6
treated	429.4	160.7	271.8	449.2	169.5	289.7	449.3	183.9	281.0
APRIL									
raw	444.7	177.3	273.0	463.6	179.5	285.5	478.0	112.0	296.1
treated	426.5	171.0	262.3	436.0	161.6	268.9	444.0	105.0	276.4
MAY									
raw	495.8	198.1	296.0	509.1	191.6	309.7	468.9	168.2	293.4
treated	463.9	182.1	279.9	471.4	180.3	287.0	435.5	154.0	272.2
JUNE									
raw	535.0	215.8	317.7	524.6	212.3	339.4	565.6	204.5	347.0
treated	494.2	206.9	300.5	481.5	201.0	316.6	546.0	189.5	323.9
JULY									
raw	567.8	202.5	326.1	616.9	168.2	347.7	542.0	173.2	342.5
treated	554.5	196.1	310.5	591.1	148.5	321.3	523.1	168.4	321.1
AUGUST									
raw	514.9	177.3	318.1	568.2	200.0	372.6	573.9	229.5	359.1
treated	491.9	173.2	302.0	555.0	187.0	352.5	524.5	213.4	335.6
SEPTEMBER									
raw	472.0	168.2	298.2	500.0	202.1	314.7	478.6	124.6	301.8
treated	439.8	154.9	282.3	461.7	187.3	294.4	454.5	105.7	282.3
OCTOBER									
raw	458.6	185.3	277.8	442.5	154.8	288.5	450.7	171.7	284.6
treated	439.2	181.3	263.7	422.6	146.4	269.7	433.5	266.6	158.6
NOVEMBER									
raw	447.5	205.1	299.8	450.5	195.3	282.8	422.7	198.8	276.4
treated	424.5	193.6	279.0	425.6	178.5	262.7	399.5	178.7	260.1
DECEMBER									
raw	456.4	128.3	272.8	418.2	118.7	268.2	424.5	140.3	280.8
treated	423.7	76.8	252.7	395.9	111.0	249.7	403.1	8.0	256.8
YEARLY AVERAGES									
raw	481.9	176.3	293.0	476.0	194.8	310.2	471.4	177.0	311.5
treated	455.1	164.4	277.6	449.0	181.7	291.0	444.5	162.8	282.0

TABLE 1.1

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT

PER CAPITA CONSUMPTION

	1986	1985	1984
POPULATION	385762	386277	381308
TOTAL PER CAPITA FLOWS: (L/DAY/CAPITA)			
MAXIMUM DAY	1437	1530	1432
MINIMUM DAY	199	287	275
AVERAGE DAY	720	753	740
RATIO MD:AD	2.0	2.0	1.9
ESTIMATED RESIDENTIAL PER CAPITA FLOWS: (L/DAY/CAPITA)			
MAXIMUM DAY	575	612	573
MINIMUM DAY	80	115	110
AVERAGE DAY	288	301	296
RATIO MD:AD	2.0	2.0	1.9

NOTES:
1. Population figures obtained from Economic Development Department of the Regional Municipality of Hamilton-Wentworth.
2. The Systems Department of the Region of Hamilton-Wentworth estimates that 40% of treated water goes to residential use and 60% is used by industry.

TABLE 2.0

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL SUMMARY

			1986			1985			1984		
			maximum	minimum	mean	maximum	minimum	mean	maximum	minimum	mean
JANUARY	Turbidity (NTU)	raw(plt)	4.7	0.4	1.2	10.5	0.9	2.8	11.0	1.3	3.0
		raw(lab)									
		treated									
	Alum Dose (mg/L)		4.1	0.8	1.9	7.2	1.8	3.6	6.6	2.6	3.9
	pH	raw									
		treated									
	Aluminum (mg/L)										
	Temperature (C)		4	2	3	4	1	3	4	1	2
FEBRUARY	Turbidity (NTU)	raw(plt)	19.4	0.5	4.3	15.5	0.9	3.9	15.0	1.0	3.3
		raw(lab)									
		treated									
	Alum Dose (mg/L)		8.9	1.0	3.8	10.4	2.0	4.2	8.7	2.3	4.1
	pH	raw									
		treated									
	Aluminum (mg/L)										
	Temperature (C)		2	1	2	3.0	1.0	2.1	4	2	3
MARCH	Turbidity (NTU)	raw(plt)	6.2	0.2	1.3	15.0	0.9	4.0	17.0	2.4	6.5
		raw(lab)									
		treated									
	Alum Dose (mg/L)		5.8	0.0	2.3	10.2	2.2	4.5	13.6	3.2	6.2
	pH	raw									
		treated									
	Aluminum (mg/L)										
	Temperature (C)		4	1	2	4	2	3	3	1	2
APRIL	Turbidity (NTU)	raw(plt)	4.4	0.2	0.8	11.0	1.4	3.4	15.0	1.9	4.7
		raw(lab)	2.4	0.6	1.0	33.0	0.7	4.1	18.0	1.3	3.8
		treated	0.50	0.18	0.32	0.90	0.20	0.36	0.70	0.24	0.39
	Alum Dose (mg/L)		4.2	1.0	1.9	10.1	2.0	4.2	10.6	3.6	7.1
	pH	raw	8.03	7.4	7.77	7.82	7.45	7.56	7.65	6.7	7.35
		treated	7.65	7.3	7.5	7.28	6.93	7.14	7.4	6.05	6.81
	Aluminum (mg/L)										
	Temperature (C)		8	4	6	8	4	5	7	3	5
MAY	Turbidity (NTU)	raw(plt)	1.5	0.3	0.7	2.0	1.2	1.5	4.2	1.3	1.9
		raw(lab)									
		treated									
	Alum Dose (mg/L)		3.4	0.9	1.8	3.9	1.8	2.6	7.3	2.7	4.2
	pH	raw									
		treated									
	Aluminum (mg/L)										
	Temperature (C)		11	6	8	11	7	9	9	5	7
JUNE	Turbidity (NTU)	raw(plt)	2.0	0.9	1.3	3.5	1.1	1.7	5.2	1.6	2.6
		raw(lab)									
		treated									
	Alum Dose (mg/L)		3.5	1.4	2.4	2.8	1.7	2.2	9.0	3.2	4.7
	pH	raw									
		treated									
	Aluminum (mg/L)										
	Temperature (C)		14	8	11	14	7	10	17	7	10

Sources: Raw water turbidity (plt))
Alum dose) Water Works Purification Plant Monthly Report
Temperature)

Treated water turbidity) Daily laboratory data sheets
pH, raw & treated)

Note: Treated water turbidity reported on 1984 laboratory sheets was measured at the Water Plant.

TABLE 2.0 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL SUMMARY

			1986			1985			1984		
			maximum	minimum	mean	maximum	minimum	mean	maximum	minimum	mean
JULY	Turbidity (NTU)	raw(plt)	3.9	0.5	1.9	2.5	0.7	1.6	3.1	1.4	2.3
		raw(lab)	1.9	0.1	1.1	3.8	1.2	2.6	2.5	1.3	1.8
		treated	0.78	0.24	0.46	0.51	0.2	0.34	0.69	0.35	0.51
	Alum Dose (mg/L)		9.3	1.6	3.4	3.5	1.5	2.6	4.8	2.9	3.6
	pH	raw	7.90	7.35	7.70	7.95	7.45	7.71	7.50	7.10	7.30
		treated	7.60	7.20	7.41	7.45	7.10	7.28	7.03	6.75	6.86
	Aluminum (mg/L)										
	Temperature (C)		20	7	14	17	7	9	13	6	8
AUGUST	Turbidity (NTU)	raw(plt)	4.2	1.5	2.7	13.0	1.1	2.7	5.5	1.2	3.1
		raw(lab)									
		treated									
	Alum Dose (mg/L)		11.5	2.0	4.7	5.7	1.8	3.2	7.9	2.8	5.5
	pH	raw									
		treated									
	Aluminum (mg/L)										
	Temperature (C)		21	12	16	22	15	19	22	9	16
SEPTEMBER	Turbidity (NTU)	raw(plt)	10.6	1.1	2.6	2.4	0.7	1.1	5.1	1.7	2.8
		raw(lab)									
		treated									
	Alum Dose (mg/L)		7.5	2.6	4.7	6.3	2.0	3.6	7.9	2.9	5.7
	pH	raw									
		treated									
	Aluminum (mg/L)										
	Temperature (C)		18	8	13	22	18	20	19	9	15
OCTOBER	Turbidity (NTU)	raw(plt)	4.3	1.1	2.0	3.3	0.4	0.8	5.8	1.6	2.5
		raw(lab)									
		treated									
	Alum Dose (mg/L)		10.9	2.1	3.7	4.7	2.2	3.3	5.7	2.8	4.4
	pH	raw									
		treated									
	Aluminum (mg/L)										
	Temperature (C)		17	7	13	16	8	11	15	9	12
NOVEMBER	Turbidity (NTU)	raw(plt)	3.7	1.1	1.7	18.1	1.0	6.2	3.9	1.5	2.0
		raw(lab)									
		treated									
	Alum Dose (mg/L)		9.0	2.5	4.2	9.2	1.6	5.1	6.5	2.3	3.4
	pH	raw									
		treated									
	Aluminum (mg/L)										
	Temperature (C)		11	6	8	12	7	10	13	7	9
DECEMBER	Turbidity (NTU)	raw(plt)	20.7	1.4	4.3	5.7	0.5	1.0	17.5	1.4	4.4
		raw(lab)	9.3	0.8	3.4	2.2	0.5	0.9	20.0	0.8	3.5
		treated	1.27	0.22	0.47	0.78	0.13	0.25	0.39	0.13	0.27
	Alum Dose (mg/L)		11.5	2.4	5.4	7.7	0.8	2.0	7.1	2.3	3.8
	pH	raw	7.88	7.60	7.74	7.85	7.10	7.63	7.43	7.15	7.30
		treated	7.49	7.10	7.33	7.70	7.10	7.41	6.93	6.58	6.76
	Aluminum (mg/L)										
	Temperature (C)		6	4	4	8	2	5	7	4	6

Sources: Raw water turbidity (plt))
Alum dose) Water Works Purification Plant Monthly Report
Temperature)

Treated water turbidity) Daily laboratory data sheets
pH, raw & treated)

Note: Treated water turbidity reported on 1984 laboratory sheets was measured at the Water Plant.

TABLE 2.1

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL PROFILE

APRIL 1986

DATE	TURBIDITY (NTU)			ALUM	pH		TEMP
	raw (lab)	raw (plant)	treat. (lab)	DOSE (mg/L)	raw	treated	(C)
01-Apr-86	0.9	0.2	0.33	1.4	7.50	7.40	
02-Apr-86		0.2		1.1			
03-Apr-86	1.0	0.8	0.32	1.4	7.40	7.30	
04-Apr-86	0.8	0.5	0.31	2.2	7.57	7.40	6
05-Apr-86	2.4	4.4	0.34	3.8	7.75	7.58	6
06-Apr-86	1.5	2.2	0.20	4.2	7.75	7.63	5
07-Apr-86	0.9	0.7	0.18	1.5	7.70	7.50	5
08-Apr-86	0.6	0.5	0.22	2.0	7.65	7.40	5
09-Apr-86	0.6	0.5	0.24	2.3	7.58	7.43	4
10-Apr-86	0.8	0.5	0.24	1.0	7.60	7.43	4
11-Apr-86	0.9	1.3	0.28	1.1	7.63	7.42	4
12-Apr-86	1.0	0.9	0.37	1.9	7.68	7.52	4
13-Apr-86	1.0	0.7	0.32	1.6	7.70	7.55	4
14-Apr-86	0.8	1.0	0.26	1.1	7.70	7.60	4
15-Apr-86	0.7	0.5	0.20	1.7	7.80	7.65	5
16-Apr-86		0.7		1.1			5
17-Apr-86	1.0	1.1	0.26	1.1	7.85	7.55	6
18-Apr-86		0.6		2.0			6
19-Apr-86		0.9		3.9			6
20-Apr-86	1.1	0.8	0.31	1.7	7.80	7.55	7
21-Apr-86	1.0	0.7	0.40	1.4	7.82	7.55	7
22-Apr-86	1.1	0.7	0.50	1.3	7.87	7.55	7
23-Apr-86	1.0	0.6	0.38	2.0	8.00	7.60	6
24-Apr-86	1.0	0.6	0.39	1.3	7.90	7.57	6
25-Apr-86	1.0	0.7	0.40	1.3	7.87	7.53	6
26-Apr-86	1.1	0.6	0.40	1.2	7.90	7.53	7
27-Apr-86	1.0	0.7	0.37	1.1	7.85	7.50	6
28-Apr-86	0.9	0.6	0.42	2.6	8.00	7.45	7
29-Apr-86	1.0	0.6	0.30	4.2	8.03	7.40	8
30-Apr-86	1.1	0.6	0.31	3.5	8.00	7.38	7
maximum	2.4	4.4	0.50	4.2	8.03	7.65	8
minimum	0.6	0.2	0.18	1.0	7.40	7.30	4
mean	1.0	0.8	0.32	1.9	7.77	7.50	6
#data	26	30	26	30	26	26	30
stan dev	0.3	0.7	0.08	1.0	0.16	0.09	1

Sources: Raw water turbidity (plant)) Water Works Purification Plant
Alum dose) Monthly Report
Temperature)

Raw water turbidity (lab))
Treated water turbidity (lab)) Daily Laboratory sheets
pH, raw & treated)

TABLE 2.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL PROFILE

JULY 1986

DATE	TURBIDITY (NTU) raw (lab)	raw (plant)	treat. (lab)	ALUM DOSE (mg/L)	pH raw	treated	TEMP (C)
01-Jul-86	1.2	1.7	0.38	1.6	7.85	7.43	8
02-Jul-86	0.1	1.6	0.45	2.0	7.80	7.45	10
03-Jul-86	1.0	1.1	0.40	2.0	7.85	7.45	16
04-Jul-86	1.0	1.5	0.57	2.0	7.85	7.50	14
05-Jul-86	1.0	1.8	0.44	1.9	7.75	7.45	8
06-Jul-86	1.0	2.1	0.38	2.2	7.75	7.45	7
07-Jul-86	1.1	1.8	0.54	1.8	7.55	7.25	7
08-Jul-86	1.0	1.4	0.27	2.3	7.45	7.20	8
09-Jul-86	1.1	0.5	0.25	2.5	7.60	7.40	7
10-Jul-86	1.1	0.8	0.34	2.1	7.70	7.25	7
11-Jul-86	1.0	1.7	0.45	2.3	7.80	7.40	11
12-Jul-86	1.3	1.9	0.55	2.7	7.90	7.40	16
13-Jul-86	1.4	1.7	0.59	3.9	7.80	7.35	17
14-Jul-86	1.2	1.8	0.72	4.0	7.45	7.35	17
15-Jul-86	0.1	1.8	0.68	4.0	7.35	7.20	12
16-Jul-86	1.3	1.6	0.65	4.1	7.35	7.30	12
17-Jul-86	1.0	1.8	0.69	3.1	7.40	7.45	13
18-Jul-86	0.8	1.5	0.57	2.5	7.50	7.40	14
19-Jul-86	1.3	1.9	0.46	3.8	7.75	7.45	15
20-Jul-86	1.2	2.3	0.45	4.6	7.65	7.40	17
21-Jul-86	1.7	2.9	0.45	4.1	7.90	7.35	20
22-Jul-86	1.9	3.1	0.43	4.0	7.60	7.45	19
23-Jul-86	1.7	2.4	0.37	3.9	7.60	7.45	19
24-Jul-86	1.4	1.9	0.39	4.0	7.55	7.45	15
25-Jul-86	0.9	1.8	0.26	3.3	7.65	7.40	14
26-Jul-86	0.8	1.7	0.25	3.2	7.85	7.45	14
27-Jul-86	0.8	1.7	0.24	2.5	7.85	7.60	14
28-Jul-86	1.2	2.2	0.42	3.5	7.85	7.55	18
29-Jul-86	1.5	2.5	0.52	3.3	7.85	7.55	18
30-Jul-86	1.8	3.8	0.78	9.3	7.90	7.55	20
31-Jul-86	1.7	3.9	0.30	7.8	7.85	7.45	20
maximum	1.9	3.9	0.78	9.3	7.90	7.60	20
minimum	0.1	0.5	0.24	1.6	7.35	7.20	7
mean	1.1	1.9	0.46	3.4	7.70	7.41	14
#data	31	31	31	31	31	31	31
stan dev	0.4	0.7	0.14	1.6	0.17	0.10	4

Sources: Raw water turbidity (plant)) Water Works Purification Plant
Alum dose) Monthly Report
Temperature)

Raw water turbidity (lab))
Treated water turbidity (lab)) Daily Laboratory sheets
pH, raw & treated)

TABLE 2.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL PROFILE

DECEMBER 1986

DATE	TURBIDITY (NTU)			ALUM	pH		TEMP
	raw (lab)	raw (plant)	treat. (lab)	DOSE (mg/L)	raw	treated	(C)
01-Dec-86		5.8					6
02-Dec-86	6.2	5.5	0.73	6.6	7.88	7.49	5
03-Dec-86	5.4	5.8	1.27	7.1	7.85	7.39	5
04-Dec-86	8.2	10.4	1.00	6.3	7.73	7.29	5
05-Dec-86	3.3	8.0	1.10	5.1	7.63	7.25	5
06-Dec-86	1.8	2.6	0.43	4.6	7.65	7.30	4
07-Dec-86	1.5	2.5	0.27	3.7	7.75	7.35	4
08-Dec-86	5.6	14.4	0.30	5.1	7.65	7.40	4
09-Dec-86	9.3	4.4	0.50	9.1	7.70	7.35	4
10-Dec-86		2.3	0.43	6.0		7.35	5
11-Dec-86	2.9	1.5	0.53	4.1	7.80	7.40	5
12-Dec-86	1.0	1.9	0.25	5.3	7.75	7.30	4
13-Dec-86	0.8	1.6	0.22	3.8	7.60	7.20	4
14-Dec-86		1.5		3.5			4
15-Dec-86	1.0	1.4	0.23	2.8	7.80	7.40	4
16-Dec-86	1.1	1.5	0.27	2.4	7.85	7.45	4
17-Dec-86	1.0	2.0	0.30	2.7	7.80	7.40	4
18-Dec-86	1.0	1.7	0.26	2.5	7.75	7.30	4
19-Dec-86		1.5		3.0			4
20-Dec-86		1.4		2.7			4
21-Dec-86		1.4		4.0			4
22-Dec-86		1.4		4.6			4
23-Dec-86		1.4		4.2			4
24-Dec-86		1.4		5.9			4
25-Dec-86		20.7		9.2			4
26-Dec-86		6.7		11.5			4
27-Dec-86	6.6	9.7	0.33	11.5	7.60	7.20	4
28-Dec-86	4.6	5.2	0.33	10.0	7.60	7.10	4
29-Dec-86	1.9	2.8	0.26	5.5	7.81	7.26	4
30-Dec-86		2.2		5.1			4
31-Dec-86		1.6		4			4
maximum	9.3	20.7	1.27	11.5	7.88	7.49	6
minimum	0.8	1.4	0.22	2.4	7.60	7.10	4
mean	3.4	4.3	0.47	5.4	7.74	7.33	4
#data	19	31	20	31	19	20	31
stan dev	2.6	4.4	0.30	2.5	0.09	0.10	1

Sources: Raw water turbidity (plant)) Water Works Purification Plant
Alum dose) Monthly Report
Temperature)

Raw water turbidity (lab))
Treated water turbidity (lab)) Daily Laboratory sheets
pH, raw & treated)

TABLE 2.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL PROFILE

APRIL 1985

DATE	TURBIDITY (NTU) raw (lab)	raw (plant)	treat. (lab)	ALUM DOSE (mg/L)	pH raw	treated	TEMP (C)
01-Apr-85	33.0	11.0	0.90	9.1	7.45	7.20	4
02-Apr-85	11.0	3.7	0.58	10.1	7.50	7.25	4
03-Apr-85	3.9	3.0	0.35	7.5	7.45	7.25	4
04-Apr-85	3.6	8.9	0.36	4.8	7.45	7.15	4
05-Apr-85	0.7	6.0	0.40	8.5	7.55	7.15	4
06-Apr-85	3.7	4.9	0.39	4.3	7.55	7.10	4
07-Apr-85	3.2	2.6	0.39	3.3	7.55	7.10	4
08-Apr-85	2.0	2.2	0.46	2.9	7.52	7.12	4
09-Apr-85	1.4	1.9	0.30	3.3	7.50	7.12	4
10-Apr-85	1.4	1.6	0.25	2.8	7.52	7.10	4
11-Apr-85	1.0	1.5	0.24	2.0	7.50	7.18	4
12-Apr-85	1.0	1.4	0.28	2.5	7.50	7.15	4
13-Apr-85	4.5	9.0	0.33	2.9	7.52	7.05	4
14-Apr-85	7.5	3.9	0.34	4.3	7.53	6.93	5
15-Apr-85	2.8	3.4	0.29	5.1	7.50	7.10	5
16-Apr-85	3.0	3.8	0.20	5.5	7.55	7.15	5
17-Apr-85	2.6	2.1	0.28	4.6	7.58	7.05	6
18-Apr-85	2.8	4.3	0.34	4.3	7.55	7.00	6
19-Apr-85		2.7		3.9			6
20-Apr-85		2.4		3.1			6
21-Apr-85		2.6		3.2			7
22-Apr-85	3.3	2.6	0.35	3.0	7.80	7.20	7
23-Apr-85	2.9	2.5	0.33	3.8	7.78	7.28	7
24-Apr-85	3.0	2.6	0.33	3.6	7.82	7.22	7
25-Apr-85	3.0	2.7	0.36	3.2	7.58	7.15	8
26-Apr-85	1.8	2.1	0.36	3.1	7.52	7.12	7
27-Apr-85	1.6	1.9	0.33	2.3	7.45	7.15	7
28-Apr-85	1.4	1.9	0.34	2.8	7.52	7.20	7
29-Apr-85	1.7	1.9	0.34	3.2	7.50	7.12	7
30-Apr-85	1.9	1.7	0.38	3.2	7.80	7.28	7
maximum	33.0	11.0	0.90	10.1	7.82	7.28	8
minimum	0.7	1.4	0.20	2.0	7.45	6.93	4
mean	4.1	3.4	0.36	4.2	7.56	7.14	5
#data	27	30	27	30	27	27	30
stan dev	6.0	2.3	0.13	2.0	0.11	0.08	1

Sources: Raw water turbidity (plant)) Water Works Purification Plant
Alum dose) Monthly Report
Temperature)

Raw water turbidity (lab))
Treated water turbidity (lab)) Daily Laboratory sheets
pH, raw & treated)

TABLE 2.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL PROFILE

JULY 1985

DATE	TURBIDITY (NTU) raw (lab)	raw (plant)	treat. (lab)	ALUM DOSE (mg/L)	pH raw	treated	TEMP (C)
01-Jul-85	1.2	1.0	0.41	3.2	7.90	7.20	17
02-Jul-85	1.2	1.7	0.40	3.1	7.95	7.20	16
03-Jul-85	1.2	1.7	0.40	2.9	7.70	7.20	13
04-Jul-85	1.7	1.8	0.48	2.8	7.75	7.25	11
05-Jul-85	2.3	1.6	0.32	3.0	7.58	7.10	8
06-Jul-85	3.0	2.0	0.23	2.8	7.55	7.30	8
07-Jul-85	2.4	1.9	0.20	3.5	7.45	7.15	8
08-Jul-85	1.9	2.0	0.22	2.8	7.50	7.10	9
09-Jul-85	1.9	1.0	0.26	3.0	7.60	7.20	8
10-Jul-85	2.1	0.7	0.27	2.4	7.70	7.25	8
11-Jul-85	1.6	1.4	0.23	2.9	7.60	7.30	8
12-Jul-85	2.6	1.5	0.29	3.1	7.50	7.35	7
13-Jul-85	3.2	1.2	0.30	2.7	7.75	7.30	7
14-Jul-85	3.1	1.2	0.31	3.5	7.65	7.30	7
15-Jul-85	3.3	1.1	0.26	2.4	7.65	7.35	7
16-Jul-85	3.2	1.4	0.28	2.8	7.85	7.30	7
17-Jul-85	3.1	1.6	0.30	2.8	7.70	7.35	7
18-Jul-85	3.3	1.7	0.34	2.8	7.80	7.35	7
19-Jul-85	3.2	1.2	0.36	2.9	7.75	7.30	7
20-Jul-85	3.1	1.2	0.32	2.7	7.80	7.30	8
21-Jul-85	2.2	1.1	0.31	3.2	7.85	7.25	8
22-Jul-85	2.6	1.6	0.33	1.9	7.85	7.35	8
23-Jul-85	3.1	2.5	0.47	1.6	7.85	7.35	9
24-Jul-85	3.5	2.2	0.48	1.5	7.45	7.30	9
25-Jul-85	3.3	2.1	0.47	1.6	7.70	7.35	8
26-Jul-85	3.4	1.0	0.51	1.7	7.65	7.30	8
27-Jul-85	3.4	1.8	0.42	1.9	7.80	7.45	9
28-Jul-85	3.8	2.1		2.0	7.75	7.35	8
29-Jul-85	3.3	1.7		1.6	7.70	7.30	8
30-Jul-85	2.3	1.3	0.39	1.8	7.80	7.25	8
31-Jul-85	1.9	2.5	0.39	2.2	7.80	7.30	11
maximum	3.8	2.5	0.51	3.5	7.95	7.45	17
minimum	1.2	0.7	0.20	1.5	7.45	7.10	7
mean	2.6	1.6	0.34	2.6	7.71	7.28	9
#data	31	31	29	31	31	31	31
stan dev	0.8	0.4	0.09	0.6	0.13	0.08	2

Sources: Raw water turbidity (plant)) Water Works Purification Plant
Alum dose) Monthly Report
Temperature)

Raw water turbidity (lab))
Treated water turbidity (lab)) Daily Laboratory sheets
pH, raw & treated)

TABLE 2.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL PROFILE

DECEMBER 1985

DATE	TURBIDITY (NTU) raw (lab)	raw (plant)	treat. (lab)	ALUM DOSE (mg/L)	pH raw	treated	TEMP (C)
01-Dec-85		5.7	0.16	7.7	7.75	7.38	7
02-Dec-85		2.5	0.13	5.8	7.70	7.15	8
03-Dec-85	1.4	1.0	0.17	1.9	7.60	7.20	8
04-Dec-85	1.1	0.9	0.30	1.0	7.75	7.45	7
05-Dec-85	1.3	0.9	0.37	2.6	7.80	7.50	7
06-Dec-85	1.2	1.2	0.26	2.2	7.75	7.55	7
07-Dec-85	1.0	1.1	0.27	1.2	7.85	7.50	7
08-Dec-85	1.0	0.6	0.23	1.6	7.75	7.45	7
09-Dec-85		1.1		1.9			7
10-Dec-85		0.7		2.0			7
11-Dec-85		1.2		1.6			7
12-Dec-85	2.2	1.1	0.41	3.5	7.25	7.20	7
13-Dec-85	1.3	0.8	0.25	2.9	7.30	7.20	7
14-Dec-85	0.8	0.8	0.78	1.7	7.10	7.10	6
15-Dec-85		0.7		1.5			6
16-Dec-85	0.8	0.8	0.22	1.8	7.40	7.25	5
17-Dec-85	0.9	0.9	0.26	2.0	7.35	7.20	4
18-Dec-85	0.8	0.5	0.28	1.5	7.45	7.15	4
19-Dec-85	0.8	0.5	0.20	2.3	7.55	7.15	5
20-Dec-85		0.6		1.6			4
21-Dec-85	0.6	0.6	0.19	1.3	7.75	7.55	4
22-Dec-85	0.6	0.6	0.14	1.2	7.80	7.60	4
23-Dec-85	0.5	0.6	0.17	1.1	7.80	7.70	4
24-Dec-85	0.5	0.6	0.17	0.8	7.83	7.70	4
25-Dec-85	0.6	0.7	0.18	2.2	7.80	7.70	4
26-Dec-85	0.6	0.6	0.19	1.5	7.85	7.70	4
27-Dec-85		0.6		1.5			4
28-Dec-85		0.6		1.0			3
29-Dec-85	0.6	0.6	0.18	0.9	7.50	7.50	3
30-Dec-85	0.5	0.6	0.21	1.2	7.75	7.40	3
31-Dec-85	0.7	0.5	0.25	1.6	7.80	7.45	2
maximum	2.2	5.7	0.78	7.7	7.85	7.70	8
minimum	0.5	0.5	0.13	0.8	7.10	7.10	2
mean	0.9	1.0	0.25	2.0	7.63	7.41	5
#data	22	31	24	31	24	24	31
stan dev	0.4	0.9	0.13	1.4	0.21	0.20	2

Sources: Raw water turbidity (plant)) Water Works Purification Plant
Alum dose) Monthly Report
Temperature)

Raw water turbidity (lab))
Treated water turbidity (lab)) Daily Laboratory sheets
pH, raw & treated)

TABLE 2.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL PROFILE

APRIL 1984

DATE	TURBIDITY (NTU) raw (lab)	raw (plant)	treat. (plant)	ALUM DOSE (mg/L)	pH raw	treated	TEMP (C)
01-Apr-84	2.5	5.1	0.32	8.4	7.50	7.00	3
02-Apr-84	2.8	5.6	0.35	7.9	7.45	6.75	3
03-Apr-84	3.1	5.2	0.39	6.6	7.55	6.75	3
04-Apr-84	3.9	7.7	0.37	6.7	7.55	6.75	3
05-Apr-84	18.0	15.0	0.49	10.6	7.45	6.85	3
06-Apr-84	16.0	8.0	0.45	9.6	7.20	7.00	4
07-Apr-84	6.1	6.0	0.39	9.5	6.75	7.00	3
08-Apr-84	3.5	4.6	0.28	9.2	6.70	6.70	3
09-Apr-84	3.8	6.6	0.28	9.4	7.30	7.05	3
10-Apr-84	3.8	4.8	0.24	9.4	7.65	7.00	4
11-Apr-84	3.3	3.3	0.24	7.7	7.65	6.95	4
12-Apr-84	2.7	3.8	0.26	7.3	7.60	6.95	4
13-Apr-84	3.0	3.6	0.29	7.1	7.10	6.70	4
14-Apr-84	2.5	4.1	0.30	6.1	7.25	6.65	4
15-Apr-84	2.3	4.0	0.30	6.1	7.40	6.70	4
16-Apr-84	3.4	5.4	0.31	6.9	7.15	7.05	4
17-Apr-84	2.8	3.8	0.35	6.6	7.15	7.10	6
18-Apr-84	2.2	3.8	0.29	7.1	6.95	6.75	5
19-Apr-84	2.2	3.1	0.36	6.5	7.00	7.40	5
20-Apr-84	1.9	2.3	0.49	6.0	7.40	6.70	6
21-Apr-84	2.4	2.7	0.30	6.3	7.30	6.65	6
22-Apr-84	3.8	5.7	0.33	7.5	7.25	6.75	6
23-Apr-84	4.2	8.7	0.50	8.8	7.25	6.05	6
24-Apr-84	4.5	4.3	0.38	8.5	7.40	6.45	7
25-Apr-84	1.6	2.2	0.52	4.8	7.55	6.70	6
26-Apr-84	1.6	1.9	0.61	4.7	7.55	6.75	5
27-Apr-84	1.6	2.6	0.58	3.6	7.55	6.75	6
28-Apr-84	1.7	2.6	0.70	4.3	7.50	6.80	6
29-Apr-84	1.3	2.3	0.55	4.8	7.65	6.85	7
30-Apr-84	1.8	2.6	0.62	6.2	7.65	6.80	7
maximum	18.0	15.0	0.70	10.6	7.65	7.40	7
minimum	1.3	1.9	0.24	3.6	6.70	6.05	3
mean	3.8	4.7	0.39	7.1	7.35	6.81	5
#data	30	30	30	30	30	30	30
stan dev	3.7	2.6	0.12	1.7	0.26	0.23	1

Sources: Raw water turbidity (plant)) Water Works Purification Plant
Alum dose) Monthly Report
Temperature)

Raw water turbidity (lab))
Treated water turbidity (plant)) Daily Laboratory sheets
pH, raw & treated)

TABLE 2.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL PROFILE

JULY 1984

DATE	TURBIDITY (NTU) raw (lab)	raw (plant)	treat. (plant)	ALUM DOSE (mg/L)	pH raw	treated	TEMP (C)
01-Jul-84	1.6	2.3	0.40	4.8	7.20	6.75	10
02-Jul-84	1.6	2.5	0.45	4.0	7.50	6.80	10
03-Jul-84	1.7	2.4	0.42	4.3	7.43	6.90	9
04-Jul-84	1.5	2.3	0.39	4.6	7.20	6.85	8
05-Jul-84	1.4	2.1	0.37	3.6	7.30	6.85	8
06-Jul-84	1.5	2.2	0.50	3.6	7.40	6.78	8
07-Jul-84	1.5	2.1	0.42	3.8	7.45	6.85	7
08-Jul-84	1.4	2.0	0.45	3.9	7.45	6.80	7
09-Jul-84	1.4	2.2	0.45	3.9	7.30	6.85	7
10-Jul-84	1.5	2.2	0.57	3.5	7.33	6.88	7
11-Jul-84	1.8	1.8	0.63	3.4	7.30	6.83	7
12-Jul-84	1.6	1.8	0.66	3.5	7.40	6.90	9
13-Jul-84	1.9	1.9	0.65	3.4	7.38	6.90	10
14-Jul-84	1.8	2.6	0.56	3.3	7.43	6.78	9
15-Jul-84	2.2	3.0	0.62	2.9	7.45	6.83	7
16-Jul-84	2.1	2.1	0.53	3.5	7.33	6.88	7
17-Jul-84	2.0	2.8	0.47	3.5	7.13	6.93	8
18-Jul-84	2.5	3.1	0.48	3.5	7.10	7.00	7
19-Jul-84	2.1	2.6	0.54	3.7	7.10	7.03	7
20-Jul-84	2.1	2.9	0.63	3.3	7.25	6.90	7
21-Jul-84	2.1	2.5	0.48	3.4	7.28	6.78	7
22-Jul-84	1.9	2.4	0.51	3.3	7.23	6.83	7
23-Jul-84	1.9	2.4	0.55	3.0	7.28	6.85	6
24-Jul-84	2.0	2.2	0.57	3.4	7.35	6.88	7
25-Jul-84	2.1	2.5	0.65	3.1	7.23	6.93	9
26-Jul-84	2.1	2.3	0.64	3.2	7.38	6.83	8
27-Jul-84	2.1	2.3	0.69	4.2	7.30	6.85	8
28-Jul-84	1.7	2.3	0.52	4.1	7.15	6.95	8
29-Jul-84	1.4	2.2	0.38	3.2	7.30	6.80	8
30-Jul-84	1.6	2.0	0.35	3.4	7.20	6.83	8
31-Jul-84	1.3	1.4	0.37	3.6	7.28	6.77	13
maximum	2.5	3.1	0.69	4.8	7.50	7.03	13
minimum	1.3	1.4	0.35	2.9	7.10	6.75	6
mean	1.8	2.3	0.51	3.6	7.30	6.86	8
#data	31	31	31	31	31	31	31
stan dev	0.3	0.4	0.10	0.4	0.11	0.06	1

Sources: Raw water turbidity (plant)) Water Works Purification Plant
Alum dose) Monthly Report
Temperature)

Raw water turbidity (lab))
Treated water turbidity (plant)) Daily Laboratory sheets
pH, raw & treated)

TABLE 2.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

PARTICULATE REMOVAL PROFILE

DECEMBER 1984

DATE	TURBIDITY (NTU)			ALUM	pH		TEMP
	raw (lab)	raw (plant)	treat. (plant)	DOSE (mg/L)	raw	treated	(C)
01-Dec-84	1.0	1.6	0.25	2.8	7.35	6.93	7
02-Dec-84	1.0	1.8	0.32	2.8	7.43	6.83	7
03-Dec-84	1.2	2.3	0.28	3.3	7.33	6.80	7
04-Dec-84	1.0	1.9	0.26	2.8	7.30	6.73	7
05-Dec-84	1.0	2.0	0.21	3.1	7.30	6.68	7
06-Dec-84	1.0	1.7	0.22	3.1	7.30	6.80	6
07-Dec-84	1.0	1.4	0.21	3.0	7.35	6.75	6
08-Dec-84	0.8	1.5	0.27	2.9	7.33	6.78	6
09-Dec-84	0.8	1.4	0.31	2.9	7.30	6.83	6
10-Dec-84	0.8	1.4	0.26	3.2	7.35	6.83	6
11-Dec-84	1.0	1.4	0.36	3.1	7.38	6.78	6
12-Dec-84	0.9	1.5	0.25	3.1	7.35	6.83	6
13-Dec-84	1.0	1.6	0.29	2.6	7.40	6.75	6
14-Dec-84	14.0	14.5	0.26	4.3	7.15	6.75	6
15-Dec-84	20.0	17.5	0.39	7.1	7.15	6.63	6
16-Dec-84	12.5	10.0	0.31	6.3	7.25	6.75	6
17-Dec-84		7.3		4.1	7.30	6.85	6
18-Dec-84		5.8	0.28	4.7	7.28	6.83	6
19-Dec-84	2.8	5.5	0.38	3.8	7.35	6.88	6
20-Dec-84	2.9	4.9	0.30	4.0	7.30	6.80	6
21-Dec-84	5.3	11.5	0.28	4.7	7.30	6.73	6
22-Dec-84	4.7	5.0	0.23	5.9	7.23	6.60	6
23-Dec-84	2.1	3.3	0.13	4.4	7.23	6.58	5
24-Dec-84	1.2	3.5	0.35	4.2	7.30	6.60	5
25-Dec-84	1.0		0.20				
26-Dec-84		2.2		3.3			4
27-Dec-84		7.0		3.9			4
28-Dec-84		3.5		4.4			4
29-Dec-84		2.5		4.4			5
30-Dec-84		2.0		3.5			5
31-Dec-84	4.3	5.3	0.16	2.3	7.20	6.75	5
maximum	20.0	17.5	0.39	7.1	7.43	6.93	7
minimum	0.8	1.4	0.13	2.3	7.15	6.58	4
mean	3.5	4.4	0.27	3.8	7.30	6.76	6
#data	24	30	25	30	25	25	30
stan dev	4.9	4.0	0.06	1.1	0.07	0.09	1

Sources: Raw water turbidity (plant)) Water Works Purification Plant
Alum dose) Monthly Report
Temperature)

Raw water turbidity (lab))
Treated water turbidity (plant)) Daily Laboratory sheets
pH, raw & treated)

TABLE 3.0

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION SUMMARY
(all units: ug/L)

MONTH	CHEMICAL	1986 maximum	1986 minimum	1986 mean	1985 maximum	1985 minimum	1985 mean	1984 maximum	1984 minimum	1984 mean
JANUARY	Pre chlorine dose	2.4	1.4	1.8	2.4	1.2	1.7	2.4	1.2	1.5
	Post chlorine dose	0.94	0.00	0.04	0.00	0.00	0.00	0.38	0.00	0.07
	Ammonia	0.24	0.18	0.21	0.22	0.12	0.20	0.20	0.14	0.15
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.01
	Cl2 Residual-plant (total)	0.83	0.68	0.78	0.90	0.66	0.81	0.83	0.58	0.68
	-lab (total)									
	-lab (free)									
	Fluoride dose	1.13	0.00	0.96	1.35	0.90	1.06	1.24	0.79	1.02
	Fluoride Residual - lab									
FEBRUARY	Pre chlorine dose	2.9	1.7	2.1	2.5	1.0	1.7	3.2	1.3	1.9
	Post chlorine dose	0.00	0.00	0.00	0.59	0.00	0.05	0.40	0.00	0.06
	Ammonia	0.23	0.20	0.21	0.21	0.12	0.19	0.17	0.14	0.16
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cl2 Residual-plant (total)	0.86	0.66	0.79	0.85	0.54	0.79	0.81	0.60	0.72
	-lab (total)									
	-lab (free)									
	Fluoride dose	1.05	0.82	0.96	1.19	0.95	1.10	1.12	0.89	1.01
	Fluoride Residual - lab									
MARCH	Pre chlorine dose	3.2	1.5	2.1	3.0	1.4	2.1	2.8	1.4	2.1
	Post chlorine dose	0.55	0.00	0.03	0.48	0.00	0.07	0.26	0.00	0.03
	Ammonia	0.24	0.12	0.21	0.24	0.18	0.21	0.22	0.15	0.20
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cl2 Residual-plant (total)	0.87	0.69	0.78	0.86	0.68	0.79	0.85	0.58	0.74
	-lab (total)									
	-lab (free)									
	Fluoride dose	1.04	0.87	0.97	1.20	0.84	1.03	1.28	0.98	1.09
	Fluoride Residual - lab									
APRIL	Pre chlorine dose	3.1	1.6	2.1	3.1	1.5	2.1	2.9	1.6	2.2
	Post chlorine dose	0.57	0.00	0.02	1.00	0.00	0.13	0.09	0.00	0.01
	Ammonia	0.23	0.20	0.21	0.21	0.18	0.20	0.24	0.19	0.21
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cl2 Residual-plant (total)	0.86	0.68	0.78	0.88	0.69	0.79	0.83	0.67	0.76
	-lab (total)	0.88	0.44	0.74	0.84	0.52	0.72	0.83	0.53	0.71
	-lab (free)	0.01	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.01
	Fluoride dose	1.04	0.00	0.87	1.21	0.82	1.02	1.20	0.92	1.07
	Fluoride Residual - lab	1.04	0.18	0.86	1.13	0.95	1.04	1.12	0.97	1.04
MAY	Pre chlorine dose	2.7	1.6	2.0	3.5	1.7	2.1	3.1	1.5	2.2
	Post chlorine dose	0.87	0.00	0.14	0.37	0.00	0.07	0.15	0.00	0.00
	Ammonia	0.24	0.19	0.22	0.80	0.00	0.19	0.23	0.19	0.22
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.01
	Cl2 Residual-plant (total)	0.91	0.71	0.81	0.89	0.65	0.79	0.89	0.69	0.80
	-lab (total)									
	-lab (free)									
	Fluoride dose	1.22	0.89	1.04	1.07	0.63	0.89	1.17	0.57	1.04
	Fluoride Residual - lab									
JUNE	Pre chlorine dose	2.5	1.0	1.6	2.7	1.3	2.1	3.9	1.6	2.2
	Post chlorine dose	1.10	0.05	0.50	0.47	0.00	0.08	0.22	0.00	0.03
	Ammonia	0.23	0.19	0.22	0.22	0.15	0.20	0.22	0.17	0.21
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.01
	Cl2 Residual-plant (total)	0.88	0.74	0.82	3.85	0.72	0.90	0.91	0.66	0.80
	-lab (total)									
	-lab (free)									
	Fluoride dose	1.19	0.00	1.03	1.05	0.84	0.93	1.12	0.91	1.01
	Fluoride Residual - lab									

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluoride Residual - lab)

TABLE 3.0 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION SUMMARY
(all units: mg/L)

MONTH	CHEMICAL	1986 maximum	1986 minimum	1986 mean	1985 maximum	1985 minimum	1985 mean	1984 maximum	1984 minimum	1984 mean
JULY	Pre chlorine dose	2.8	1.0	1.9	3.1	1.6	2.1	2.7	1.7	2.0
	Post chlorine dose	1.50	0.00	0.43	0.84	0.00	0.10	0.15	0.00	0.01
	Ammonia	0.23	0.13	0.20	0.23	0.19	0.21	0.22	0.18	0.20
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cl2 Residual-plant (total)	0.85	0.55	0.77	0.96	0.73	0.82	0.91	0.76	0.82
	-lab (total)	0.78	0.26	0.58	1.03	0.59	0.80	0.85	0.58	0.74
	-lab (free)	0.09	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	Fluoride dose	1.16	0.00	0.85	1.10	0.82	0.94	1.04	0.87	0.96
	Fluoride Residual - lab	1.15	0.31	1.00	1.60	0.86	1.02	1.07	0.88	0.99
AUGUST	Pre chlorine dose	3.5	1.8	2.7	2.9	1.8	2.4	3.4	1.9	2.5
	Post chlorine dose	0.59	0.00	0.13	0.36	0.00	0.07	0.35	0.00	0.10
	Ammonia	0.26	0.12	0.22	0.22	0.18	0.20	0.22	0.19	0.20
	Sulphur Dioxide	0.40	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
	Cl2 Residual-plant (total)	0.99	0.56	0.78	0.88	0.72	0.81	0.93	0.68	0.81
	-lab (total)									
	-lab (free)									
	Fluoride dose	1.24	0.00	0.85	1.11	0.84	0.98	1.11	0.79	0.94
	Fluoride Residual - lab									
SEPTEMBER	Pre chlorine dose	2.4	1.8	2.1	3.2	1.9	2.3	2.8	1.8	2.2
	Post chlorine dose	0.47	0.00	0.11	0.39	0.00	0.04	0.23	0.00	0.03
	Ammonia	0.27	0.21	0.23	0.21	0.19	0.20	0.23	0.14	0.21
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cl2 Residual-plant (total)	0.90	0.60	0.81	0.95	0.69	0.79	0.91	0.56	0.80
	-lab (total)									
	-lab (free)									
	Fluoride dose	1.09	0.88	0.98	1.02	0.84	0.94	1.21	0.63	0.98
	Fluoride Residual - lab									
OCTOBER	Pre chlorine dose	2.7	1.9	2.2	3.1	1.4	1.9	4.1	1.6	2.6
	Post chlorine dose	0.45	0.00	0.13	0.56	0.00	0.04	0.35	0.00	0.01
	Ammonia	0.25	0.19	0.23	0.29	0.18	0.21	0.23	0.16	0.21
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cl2 Residual-plant (total)	0.91	0.61	0.83	0.88	0.73	0.80	0.92	0.63	0.78
	-lab (total)									
	-lab (free)									
	Fluoride dose	1.11	0.83	1.01	1.15	0.82	0.96	1.24	0.00	0.99
	Fluoride Residual - lab									
NOVEMBER	Pre chlorine dose	2.3	1.6	2.0	2.9	1.7	2.2	3.6	1.8	2.3
	Post chlorine dose	0.12	0.00	0.02	0.18	0.00	0.01	0.84	0.00	0.10
	Ammonia	0.25	0.03	0.22	0.23	0.20	0.21	0.30	0.19	0.22
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.03
	Cl2 Residual-plant (total)	0.91	0.57	0.81	0.86	0.74	0.81	1.14	0.68	0.81
	-lab (total)									
	-lab (free)									
	Fluoride dose	4.30	3.19	3.91	1.05	0.00	0.90	1.17	0.89	1.07
	Fluoride Residual - lab									
DECEMBER	Pre chlorine dose	2.1	1.6	1.8	2.2	1.4	1.8	2.4	1.5	2.0
	Post chlorine dose	0.27	0.00	0.06	0.00	0.00	0.00	0.36	0.00	0.06
	Ammonia	0.56	0.10	0.29	0.24	0.09	0.21	0.23	0.20	0.21
	Sulphur Dioxide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cl2 Residual-plant (total)	0.90	0.63	0.83	0.90	0.65	0.81	0.89	0.68	0.81
	-lab (total)	0.96	0.54	0.78	0.90	0.60	0.78	0.95	0.48	0.72
	-lab (free)	0.08	0.00	0.00	0.47	0.00	0.02	0.05	0.00	0.00
	Fluoride dose	1.10	0.00	0.95	1.13	0.88	0.99	1.15	0.98	1.06
	Fluoride Residual - lab	1.02	0.86	0.95	1.08	0.89	0.99	1.17	0.98	1.06

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets

TABLE 3.1

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION PROFILE

APRIL 1986

DATE	CHLORINE DOSE pre (mg/L)	CHLORINE DOSE post (mg/L)	AMMONIA DOSE (mg/L)	SULPHUR DIOXIDE DOSE (mg/L)	CHLORINE RESIDUAL plant total	CHLORINE RESIDUAL lab free (mg/L)	CHLORINE RESIDUAL lab total	FLUORIDE DOSE (mg/L)	FLUORIDE RESIDUAL (mg/L)
01-Apr-86	1.9	0.00	0.21	0.00	0.75	0.00	0.71	1.03	1.03
02-Apr-86	1.7	0.00	0.21	0.00	0.77			1.02	
03-Apr-86	1.7	0.00	0.21	0.00	0.81	0.00	0.77	1.02	0.98
04-Apr-86	2.2	0.00	0.21	0.00	0.78	0.00	0.73	0.98	1.02
05-Apr-86	1.8	0.00	0.20	0.00	0.76	0.00	0.81	0.95	1.00
06-Apr-86	2.2	0.00	0.22	0.00	0.84	0.00	0.84	1.00	1.03
07-Apr-86	2.0	0.00	0.22	0.00	0.77	0.00	0.88	0.99	1.04
08-Apr-86	1.9	0.00	0.22	0.00	0.77	0.00	0.64		0.18
09-Apr-86	2.2	0.00	0.21	0.00	0.76	0.00	0.69		0.22
10-Apr-86	2.1	0.00	0.22	0.00	0.80	0.00	0.74		0.20
11-Apr-86	1.9	0.00	0.22	0.00	0.83	0.00	0.78	1.04	0.41
12-Apr-86	1.6	0.00	0.21	0.00	0.82	0.00	0.84	0.94	0.92
13-Apr-86	1.8	0.00	0.23	0.00	0.86	0.00	0.68	1.01	1.01
14-Apr-86	1.7	0.00	0.22	0.00	0.80	0.00	0.76	0.98	0.98
15-Apr-86	1.7	0.00	0.21	0.00	0.78	0.00	0.76	0.93	0.95
16-Apr-86	2.3	0.00	0.21	0.00	0.72			0.92	
17-Apr-86	2.3	0.00	0.21	0.00	0.72	0.00	0.78	0.91	0.98
18-Apr-86	1.9	0.00	0.21	0.00	0.76			0.95	
19-Apr-86	1.8	0.00	0.21	0.00	0.78			0.98	
20-Apr-86	2.4	0.00	0.22	0.00	0.75	0.00	0.79	1.03	0.94
21-Apr-86	2.7	0.00	0.23	0.00	0.81	0.00	0.80	0.96	0.95
22-Apr-86	3.1	0.00	0.21	0.00	0.75	0.00	0.71	0.89	0.90
23-Apr-86	2.3	0.00	0.21	0.00	0.68	0.01	0.44	0.92	0.88
24-Apr-86	2.8	0.57	0.21	0.00	0.78	0.00	0.58	0.92	0.94
25-Apr-86	2.2	0.00	0.21	0.00	0.79	0.00	0.70	0.91	0.99
26-Apr-86	1.7	0.00	0.20	0.00	0.86	0.00	0.80	0.95	1.01
27-Apr-86	2.1	0.00	0.22	0.00	0.82	0.00	0.84	0.99	0.99
28-Apr-86	2.6	0.00	0.23	0.00	0.80	0.00	0.75	1.01	0.95
29-Apr-86	3.1	0.00	0.22	0.00	0.72	0.00	0.80	0.98	0.96
30-Apr-86	2.1	0.00	0.22	0.00	0.73	0.00	0.70	0.95	0.96
maximum	3.1	0.57	0.23	0.00	0.86	0.01	0.88	1.04	1.04
minimum	1.6	0.00	0.20	0.00	0.68	0.00	0.44	0.89	0.18
mean	2.1	0.02	0.21	0.00	0.78	0.00	0.74	0.97	0.86
#data	30	30	30	30	30	26	26	27	26
stan dev	0.4	0.10	0.01	0.00	0.04	0.00	0.09	0.04	0.27

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluoride Residual - lab)

TABLE 3.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION PROFILE

JULY 1986

DATE	CHLORINE DOSE		AMMONIA DOSE	SULPHUR DIOXIDE DOSE	CHLORINE RESIDUAL			FLUORIDE DOSE	FLUORIDE RESIDUAL
	pre (mg/L)	post	(mg/L)	(mg/L)	plant total	lab free (mg/L)	lab total	(mg/L)	(mg/L)
01-Jul-86	1.1	0.70	0.22	0.00	0.85	0.00	0.70	1.08	1.09
02-Jul-86	1.3	0.69	0.19	0.00	0.83	0.00	0.68	1.04	1.05
03-Jul-86	1.1	0.94	0.16	0.00	0.73	0.00	0.58	1.09	1.10
04-Jul-86	1.4	1.40	0.13	0.00	0.81	0.09	0.34	1.06	0.94
05-Jul-86	1.0	1.50	0.17	0.00	0.75	0.00	0.47	1.01	1.00
06-Jul-86	1.0	1.20	0.20	0.00	0.72	0.00	0.68	1.10	1.00
07-Jul-86	1.3	1.10	0.20	0.00	0.74	0.00	0.78	1.00	1.05
08-Jul-86	1.2	0.80	0.21	0.00	0.85	0.00	0.49	1.16	0.84
09-Jul-86	1.0	0.60	0.16	0.00	0.69	0.00	0.65	1.09	1.00
10-Jul-86	1.3	0.70	0.21	0.00	0.83	0.00	0.49	1.01	0.87
11-Jul-86	2.1	0.50	0.21	0.00	0.77	0.00	0.74	1.09	1.03
12-Jul-86	2.3	0.30	0.20	0.00	0.83	0.00	0.68	1.08	1.05
13-Jul-86	2.3	0.00	0.20	0.00	0.82	0.00	0.76	1.04	1.01
14-Jul-86	2.4	0.00	0.21	0.00	0.74	0.00	0.53	1.01	1.08
15-Jul-86	2.5	0.00	0.21	0.00	0.76	0.00	0.42	1.00	1.15
16-Jul-86	1.9	0.00	0.21	0.00	0.67	0.00	0.37	1.08	1.01
17-Jul-86	2.2	0.00	0.17	0.00	0.72	0.00	0.38	1.06	1.02
18-Jul-86	2.0	0.00	0.21	0.00	0.69	0.00	0.42	1.02	1.06
19-Jul-86	1.9	0.28	0.20	0.00	0.77	0.00	0.74	1.10	1.04
20-Jul-86	2.3	0.00	0.21	0.00	0.78	0.00	0.73	1.07	1.06
21-Jul-86	2.4	0.31	0.22	0.00	0.79	0.00	0.59	1.07	1.03
22-Jul-86	2.8	0.43	0.23	0.00	0.83	0.00	0.49	1.12	1.08
23-Jul-86	2.5	0.23	0.19	0.00	0.83	0.00	0.55	0.94	1.06
24-Jul-86	2.5	0.17	0.21	0.00	0.81	0.00	0.52	1.10	1.01
25-Jul-86	2.3	0.10	0.21	0.00	0.78	0.00	0.61	0.84	1.00
26-Jul-86	2.3	0.00	0.20	0.00	0.79	0.00	0.66		0.31
27-Jul-86	2.3	0.18	0.22	0.00	0.74	0.00	0.75		
28-Jul-86	2.1	0.19	0.22	0.00	0.81	0.00	0.75		
29-Jul-86	2.2	0.17	0.21	0.00	0.80	0.00	0.68		
30-Jul-86	2.4	0.02	0.21	0.00	0.70	0.00	0.63		
31-Jul-86	2.0	0.72	0.18	0.00	0.55	0.00	0.26		
maximum	2.8	1.50	0.23	0.00	0.85	0.09	0.78	1.16	1.15
minimum	1.0	0.00	0.13	0.00	0.55	0.00	0.26	0.84	0.31
mean	1.9	0.43	0.20	0.00	0.77	0.00	0.58	1.05	1.00
#data	31	31	31	31	31	31	31	25	26
stan dev	0.6	0.44	0.02	0.00	0.06	0.02	0.14	0.06	0.15

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluoride Residual - lab)

TABLE 3.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION PROFILE

DECEMBER 1986

DATE	CHLORINE DOSE		AMMONIA DOSE	SULPHUR DIOXIDE DOSE	CHLORINE RESIDUAL			FLUORIDE DOSE	FLUORIDE RESIDUAL
	pre (mg/L)	post	(mg/L)	(mg/L)	plant total	lab free (mg/L)	lab total	(mg/L)	(mg/L)
01-Dec-86	1.9	0.04	0.10	0.00	0.83	0.08	0.54	0.94	0.98
02-Dec-86	2.0	0.04	0.24	0.00	0.80	0.00	0.88	1.01	0.97
03-Dec-86	1.9	0.04	0.24	0.00	0.82	0.00	0.82	1.02	0.94
04-Dec-86	2.0	0.04	0.23	0.00	0.78	0.00	0.84	0.98	0.94
05-Dec-86	2.0	0.12	0.23	0.00	0.78	0.00	0.72	1.02	0.94
06-Dec-86	1.7	0.00	0.23	0.00	0.88	0.00	0.85	1.01	1.00
07-Dec-86	1.6	0.00	0.23	0.00	0.82	0.00	0.84	1.03	0.97
08-Dec-86	1.8	0.05	0.24	0.00	0.88	0.00	0.84	1.10	0.97
09-Dec-86	1.7	0.27	0.25	0.00	0.85	0.00	0.68	1.01	0.95
10-Dec-86	1.7	0.27	0.24	0.00	0.84	0.00	0.87	0.98	1.01
11-Dec-86	1.7	0.27	0.24	0.00	0.78	0.00	0.78	0.90	1.02
12-Dec-86	2.0	0.00	0.25	0.00	0.79	0.00	0.66	1.01	0.95
13-Dec-86	1.7	0.00	0.23	0.00	0.84	0.00	0.64	0.89	0.92
14-Dec-86	1.7	0.00	0.23	0.00	0.90			0.97	
15-Dec-86	1.9	0.04	0.24	0.00	0.84	0.00	0.81	1.00	0.92
16-Dec-86	1.7	0.06	0.26	0.00	0.86	0.00	0.69	1.05	0.93
17-Dec-86	1.7	0.02	0.25	0.00	0.87	0.00	0.75	1.01	1.00
18-Dec-86	1.8	0.04	0.24	0.00	0.85	0.00	0.73	0.97	0.94
19-Dec-86	1.9	0.14	0.23	0.00	0.90			0.94	
20-Dec-86	1.6	0.00	0.21	0.00	0.86			0.97	
21-Dec-86	1.7	0.00	0.22	0.00	0.80			1.03	
22-Dec-86	1.8	0.00	0.22	0.00	0.79			0.96	
23-Dec-86	1.8	0.00	0.22	0.00	0.85			0.92	
24-Dec-86	1.9	0.11	0.25	0.00	0.82			1.01	
25-Dec-86	1.8	0.00	0.25	0.00	0.82			0.00	
26-Dec-86	2.1	0.05	0.53	0.00	0.80			0.95	
27-Dec-86	1.9	0.00	0.55	0.00	0.86	0.00	0.89	1.02	0.93
28-Dec-86	2.0	0.00	0.56	0.00	0.88	0.00	0.96	1.03	0.86
29-Dec-86	1.8	0.04	0.47	0.00	0.83	0.00	0.81	0.87	0.89
30-Dec-86	1.7	0.00	0.47	0.00	0.88			0.92	
31-Dec-86	1.9	0.07	0.52	0.00	0.87			0.99	
maximum	2.1	0.27	0.56	0.00	0.90	0.08	0.96	1.10	1.02
minimum	1.6	0.00	0.10	0.00	0.63	0.00	0.54	0.00	0.86
mean	1.8	0.06	0.29	0.00	0.83	0.00	0.78	0.95	0.95
#data	31	31	31	31	31	20	20	31	20
stan dev	0.1	0.08	0.12	0.00	0.05	0.02	0.10	0.18	0.04

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluoride Residual - lab)

TABLE 3.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION PROFILE

APRIL 1985

DATE	CHLORINE DOSE		AMMONIA DOSE	SULPHUR DIOXIDE DOSE	CHLORINE RESIDUAL			FLUORIDE DOSE	FLUORIDE RESIDUAL
	pre (mg/L)	post (mg/L)	(mg/L)	(mg/L)	plant total	lab free (mg/L)	lab total	(mg/L)	(mg/L)
01-Apr-85	2.6	0.17	0.21	0.00	0.73	0.00	0.70	1.19	1.09
02-Apr-85	2.4	0.19	0.21	0.00	0.77	0.00	0.72	1.00	1.03
03-Apr-85	2.1	0.00	0.20	0.00	0.75	0.00	0.83	0.91	1.02
04-Apr-85	2.2	0.42	0.20	0.00	0.75	0.00	0.68	0.90	1.02
05-Apr-85	2.1	0.00	0.19	0.00	0.73	0.00	0.74	0.90	0.96
06-Apr-85	2.0	0.00	0.19	0.00	0.80	0.00	0.68	1.03	0.98
07-Apr-85	2.1	0.36	0.20	0.00	0.77	0.00	0.72	1.09	1.02
08-Apr-85	1.8	0.00	0.20	0.00	0.79	0.00	0.81	1.02	1.06
09-Apr-85	2.1	0.18	0.20	0.00	0.69	0.00	0.70	1.05	1.01
10-Apr-85	1.9	0.00	0.20	0.00	0.76	0.00	0.76	1.05	1.02
11-Apr-85	1.8	0.00	0.20	0.00	0.80	0.00	0.84	0.99	1.05
12-Apr-85	2.0	0.00	0.20	0.00	0.81	0.00	0.80	1.07	1.09
13-Apr-85	1.5	0.00	0.19	0.00	0.84	0.00	0.84	1.04	0.99
14-Apr-85	1.7	0.00	0.20	0.00	0.82	0.00	0.81	1.09	1.08
15-Apr-85	1.7	0.32	0.20	0.00	0.81	0.00	0.74	1.09	1.12
16-Apr-85	1.8	0.31	0.18	0.00	0.82	0.00	0.65	0.82	0.97
17-Apr-85	2.3	0.24	0.20	0.00	0.79	0.00	0.56	1.12	1.02
18-Apr-85	1.8	0.18	0.20	0.00	0.74	0.00	0.60	1.09	1.02
19-Apr-85	2.5	0.00	0.20	0.00	0.84			1.01	
20-Apr-85	2.0	0.00	0.20	0.00	0.83			1.08	
21-Apr-85	2.1	0.45	0.18	0.00	0.84			1.11	
22-Apr-85	3.0	1.00	0.20	0.00	0.72	0.00	0.70	1.21	1.13
23-Apr-85	3.1	0.00	0.21	0.00	0.75	0.00		0.99	1.08
24-Apr-85	3.1	0.00	0.21	0.00	0.78	0.00	0.52	0.98	1.06
25-Apr-85	2.8	0.00	0.21	0.00	0.81	0.00	0.56	1.01	1.08
26-Apr-85	2.2	0.00	0.20	0.00	0.86	0.00	0.70	0.95	0.96
27-Apr-85	1.9	0.00	0.20	0.00	0.88	0.00	0.75	1.00	0.95
28-Apr-85	1.6	0.00	0.21	0.00	0.79	0.00	0.80	1.01	1.08
29-Apr-85	1.6	0.00	0.21	0.00	0.84	0.00	0.72	0.95	1.02
30-Apr-85	1.9	0.00	0.21	0.00	0.84	0.00	0.76	0.99	1.06
maximum	3.1	1.00	0.21	0.00	0.88	0.00	0.84	1.21	1.13
minimum	1.5	0.00	0.18	0.00	0.69	0.00	0.52	0.82	0.95
mean	2.1	0.13	0.20	0.00	0.79	0.00	0.72	1.02	1.04
#data	30	30	30	30	30	27	26	30	27
stan dev	0.4	0.22	0.01	0.00	0.05	0.00	0.09	0.08	0.05

Sources: Chedical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluorice Residual - lab)

TABLE 3.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION PROFILE

JULY 1985

DATE	CHLORINE DOSE		AMMONIA DOSE	SULPHUR DIOXIDE DOSE	CHLORINE RESIDUAL			FLUORIDE DOSE	FLUORIDE RESIDUAL
	pre (mg/L)	post	(mg/L)	(mg/L)	plant total	lab free (mg/L)	lab total	(mg/L)	(mg/L)
01-Jul-85	3.1	0.84	0.23	0.00	0.74	0.00	0.98	0.90	0.98
02-Jul-85	2.7	0.69	0.22	0.00	0.75	0.00	1.03	0.82	0.97
03-Jul-85	2.5	0.00	0.21	0.00	0.77	0.00	0.81	0.92	0.98
04-Jul-85	2.8	0.00	0.20	0.00	0.79	0.00	0.90	0.97	1.04
05-Jul-85	2.3	0.00	0.20	0.00	0.82	0.01	0.97	0.89	0.92
06-Jul-85	2.2	0.00	0.19	0.00	0.84	0.01	0.93	0.90	0.88
07-Jul-85	1.9	0.14	0.20	0.00	0.73	0.02	0.72	1.10	1.08
08-Jul-85	1.6	0.30	0.19	0.00	0.79	0.00	0.77	0.88	0.96
09-Jul-85	2.1	0.05	0.21	0.00	0.80	0.00	0.89	0.96	0.98
10-Jul-85	2.0	0.00	0.20	0.00	0.81	0.00	0.86	0.87	1.01
11-Jul-85	2.2	0.00	0.21	0.00	0.74	0.00	0.89	0.90	0.99
12-Jul-85	2.3	0.20	0.21	0.00	0.87	0.00	0.91	0.91	0.90
13-Jul-85	1.6	0.00	0.20	0.00	0.81	0.00	0.81	0.99	1.00
14-Jul-85	1.7	0.00	0.19	0.00	0.79	0.00	0.76	0.94	0.99
15-Jul-85	1.8	0.20	0.20	0.00	0.79	0.00	0.69	0.88	1.02
16-Jul-85	2.0	0.00	0.21	0.00	0.87	0.00	0.82	1.01	1.04
17-Jul-85	1.8	0.00	0.23	0.00	0.78	0.01	0.64	1.01	1.03
18-Jul-85	2.2	0.00	0.22	0.00	0.84	0.02	0.68	0.92	1.02
19-Jul-85	2.3	0.00	0.23	0.00	0.90	0.01	0.92	1.04	0.98
20-Jul-85	1.9	0.00	0.23	0.00	0.96	0.00	0.89	0.98	0.97
21-Jul-85	1.8	0.00	0.23	0.00	0.73	0.00	0.66	0.92	1.02
22-Jul-85	2.3	0.18	0.20	0.00	0.79	0.00	0.59	0.92	0.92
23-Jul-85	2.3	0.17	0.23	0.00	0.78	0.00	0.74	0.95	0.86
24-Jul-85	2.2	0.18	0.23	0.00	0.79	0.00	0.65	0.92	0.92
25-Jul-85	2.0	0.18	0.22	0.00	0.87	0.00	0.74	0.90	0.92
26-Jul-85	2.0	0.00	0.23	0.00	0.83	0.00	0.64	1.00	1.01
27-Jul-85	1.8	0.00	0.21	0.00	0.90	0.00	0.80	0.96	1.20
28-Jul-85	1.8	0.00	0.21	0.00	0.66	0.00	0.71	0.96	1.60
29-Jul-85	1.9	0.00	0.23	0.00	0.89	0.00	0.82	0.91	1.39
30-Jul-85	2.0	0.00	0.20	0.00	0.87	0.00	0.85	0.92	1.10
31-Jul-85	2.3	0.00	0.20	0.00	0.89	0.00	0.80	0.94	1.03
maximum	3.1	0.84	0.23	0.00	0.96	0.02	1.03	1.10	1.60
minimum	1.6	0.00	0.19	0.00	0.73	0.00	0.59	0.82	0.86
mean	2.1	0.10	0.21	0.00	0.82	0.00	0.80	0.94	1.02
#data	31	31	31	31	31	31	31	31	31
stan dev	0.3	0.20	0.01	0.00	0.06	0.01	0.11	0.06	0.14

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluoride Residual - lab)

TABLE 3.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION PROFILE

DECEMBER 1985

DATE	CHLORINE DOSE pre (mg/L)	CHLORINE DOSE post (mg/L)	AMMONIA DOSE (mg/L)	SULPHUR DIOXIDE DOSE (mg/L)	CHLORINE RESIDUAL plant total	CHLORINE RESIDUAL lab free (mg/L)	CHLORINE RESIDUAL lab total	FLUORIDE DOSE (mg/L)	FLUORIDE RESIDUAL (mg/L)
01-Dec-85	1.8	0.00	0.21	0.00	0.85	0.00	0.84	1.08	1.06
02-Dec-85	2.0	0.00	0.21	0.00	0.80	0.00	0.73	0.93	0.99
03-Dec-85	2.0	0.00	0.11	0.00	0.81	0.00	0.72	0.91	0.89
04-Dec-85	2.0	0.00	0.09	0.00	0.90	0.47	0.70	0.93	0.98
05-Dec-85	1.9	0.00	0.21	0.00	0.80	0.00	0.77	0.99	1.00
06-Dec-85	1.7	0.00	0.21	0.00	0.81	0.00	0.72	0.96	0.98
07-Dec-85	1.7	0.00	0.21	0.00	0.86	0.00	0.78	0.97	0.98
08-Dec-85	1.5	0.00	0.22	0.00	0.88	0.00	0.86	1.02	0.96
09-Dec-85	2.1	0.00	0.22	0.00	0.82			1.05	
10-Dec-85	2.0	0.00	0.22	0.00	0.81			0.99	
11-Dec-85	2.0	0.00	0.22	0.00	0.83			0.98	
12-Dec-85	2.2	0.00	0.22	0.00	0.84	0.01	0.71	0.99	0.99
13-Dec-85	1.9	0.00	0.23	0.00	0.82	0.00	0.77	0.91	1.01
14-Dec-85	1.7	0.00	0.21	0.00	0.84	0.04	0.74	0.98	0.99
15-Dec-85	2.0	0.00	0.21	0.00	0.86			1.07	
16-Dec-85	1.8	0.00	0.22	0.00	0.84	0.00	0.90	1.10	1.00
17-Dec-85	2.0	0.00	0.22	0.00	0.81	0.00	0.81	0.92	0.94
18-Dec-85	2.0	0.00	0.20	0.00	0.69	0.00	0.79	1.05	0.96
19-Dec-85	1.9	0.00	0.20	0.00	0.65	0.00	0.60	1.00	1.03
20-Dec-85	1.9	0.00	0.22	0.00	0.79			0.98	
21-Dec-85	1.8	0.00	0.24	0.00	0.83	0.00	0.87	1.13	0.96
22-Dec-85	1.4	0.00	0.22	0.00	0.83	0.00	0.90	0.97	1.01
23-Dec-85	1.8	0.00	0.22	0.00	0.80	0.00	0.79	0.97	0.92
24-Dec-85	1.8	0.00	0.22	0.00	0.83	0.00	0.90	1.08	0.95
25-Dec-85	2.2	0.00	0.21	0.00	0.70	0.00	0.77	0.88	0.96
26-Dec-85	2.0	0.00	0.22	0.00	0.68	0.00	0.79	1.01	1.02
27-Dec-85	1.7	0.00	0.21	0.00	0.84			1.01	
28-Dec-85	1.5	0.00	0.21	0.00	0.82			0.99	
29-Dec-85	1.5	0.00	0.22	0.00	0.88	0.00	0.89	0.97	1.01
30-Dec-85	1.8	0.00	0.18	0.00	0.83	0.00	0.74	0.99	1.08
31-Dec-85	1.4	0.00	0.16	0.00	0.80	0.00	0.64	0.96	1.08
maximum	2.2	0.00	0.24	0.00	0.90	0.47	0.90	1.13	1.08
minimum	1.4	0.00	0.09	0.00	0.65	0.00	0.60	0.88	0.89
mean	1.8	0.00	0.21	0.00	0.81	0.02	0.78	0.99	0.99
#data	31	31	31	31	31	24	24	31	24
stan dev	0.2	0.00	0.03	0.00	0.06	0.09	0.08	0.06	0.04

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluoride Residual - lab)

TABLE 3.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION PROFILE

APRIL 1984

DATE	CHLORINE DOSE		AMMONIA DOSE	SULPHUR DIOXIDE DOSE	CHLORINE RESIDUAL			FLUORIDE DOSE	FLUORIDE RESIDUAL
	pre (mg/L)	post	(mg/L)	(mg/L)	plant total	lab free (mg/L)	lab total	(mg/L)	(mg/L)
01-Apr-84	1.9	0.00	0.19	0.00	0.71	0.00	0.70	1.12	1.02
02-Apr-84	2.1	0.00	0.19	0.00	0.79	0.00	0.68	1.10	1.01
03-Apr-84	2.5	0.00	0.22	0.00	0.79	0.00	0.72	1.11	1.07
04-Apr-84	2.8	0.00	0.22	0.00	0.78	0.00	0.77	1.05	1.08
05-Apr-84	2.6	0.00	0.22	0.00	0.78	0.00	0.72	1.08	1.06
06-Apr-84	2.4	0.00	0.21	0.00	0.73	0.20	0.63	1.08	1.03
07-Apr-84	2.6	0.00	0.21	0.00	0.82	0.00	0.78	1.18	1.10
08-Apr-84	2.7	0.00	0.19	0.00	0.67	0.00	0.67	1.20	1.07
09-Apr-84	2.3	0.00	0.21	0.00	0.68	0.03	0.58	1.05	0.97
10-Apr-84	1.9	0.00	0.22	0.00	0.75	0.00	0.71	1.06	1.04
11-Apr-84	1.8	0.00	0.21	0.00	0.74	0.00	0.68	1.14	1.03
12-Apr-84	1.7	0.00	0.21	0.00	0.75	0.00	0.69	0.98	1.02
13-Apr-84	2.0	0.00	0.21	0.00	0.81	0.00	0.79	1.02	1.01
14-Apr-84	1.9	0.00	0.20	0.00	0.81	0.00	0.83	1.08	1.04
15-Apr-84	1.6	0.00	0.21	0.00	0.75	0.00	0.82	1.04	1.04
16-Apr-84	2.1	0.00	0.22	0.00	0.74	0.00	0.75	1.01	1.00
17-Apr-84	2.6	0.00	0.22	0.00	0.69	0.00	0.53	1.03	1.04
18-Apr-84	2.4	0.08	0.20	0.00	0.77	0.00	0.68	1.03	1.02
19-Apr-84	2.2	0.00	0.21	0.00	0.78	0.00	0.75	1.00	1.03
20-Apr-84	1.9	0.09	0.20	0.00	0.77	0.00	0.68	1.03	1.00
21-Apr-84	2.4	0.00	0.20	0.00	0.77	0.00	0.76	1.04	1.02
22-Apr-84	2.7	0.00	0.22	0.00	0.69	0.09	0.56	1.05	1.12
23-Apr-84	2.9	0.00	0.21	0.00	0.76	0.00	0.59	0.92	1.00
24-Apr-84	2.1	0.00	0.21	0.00	0.80	0.00	0.72	1.04	1.00
25-Apr-84	2.1	0.00	0.21	0.00	0.78	0.00	0.75	0.99	1.05
26-Apr-84	1.8	0.00	0.21	0.00	0.79	0.00	0.72	1.16	1.04
27-Apr-84	1.9	0.00	0.21	0.00	0.78	0.00	0.74	1.19	1.08
28-Apr-84	1.6	0.00	0.20	0.00	0.81	0.00	0.75	1.07	1.08
29-Apr-84	2.1	0.00	0.23	0.00	0.81	0.00	0.81	1.14	1.08
30-Apr-84	2.1	0.00	0.24	0.00	0.83	0.00	0.79	1.05	1.07
maximum	2.9	0.09	0.24	0.00	0.83	0.20	0.83	1.20	1.12
minimum	1.6	0.00	0.19	0.00	0.67	0.00	0.53	0.92	0.97
mean	2.2	0.01	0.21	0.00	0.76	0.01	0.71	1.07	1.04
#data	30	30	30	30	30	30	30	30	30
stan dev	0.4	0.02	0.01	0.00	0.04	0.04	0.07	0.06	0.03

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluoride Residual - lab)

TABLE 3.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION PROFILE

JULY 1984

DATE	CHLORINE DOSE		AMMONIA DOSE	SULPHUR DIOXIDE DOSE	CHLORINE RESIDUAL			FLUORIDE DOSE	FLUORIDE RESIDUAL
	pre (mg/L)	post	(mg/L)	(mg/L)	plant total	lab free (mg/L)	lab total	(mg/L)	(mg/L)
01-Jul-84	2.7	0.00	0.21	0.00	0.78	0.00	0.63	0.87	0.94
02-Jul-84	2.2	0.00	0.20	0.00	0.89	0.00	0.73	1.01	0.98
03-Jul-84	2.0	0.00	0.21	0.00	0.81	0.00	0.82	0.95	0.99
04-Jul-84	2.4	0.00	0.22	0.00	0.81	0.00	0.76	1.00	1.06
05-Jul-84	2.1	0.00	0.19	0.00	0.84	0.00	0.84	0.83	0.93
06-Jul-84	2.2	0.00	0.19	0.00	0.79	0.00	0.77	0.91	1.04
07-Jul-84	2.0	0.00	0.20	0.00	0.76	0.00	0.77	0.95	0.88
08-Jul-84	1.9	0.00	0.21	0.00	0.91	0.00	0.85	1.03	1.02
09-Jul-84	2.1	0.00	0.21	0.00	0.83	0.00	0.76	1.01	1.04
10-Jul-84	1.8	0.00	0.20	0.00	0.80	0.00	0.58	0.93	0.96
11-Jul-84	1.8	0.00	0.20	0.00	0.76	0.00	0.65	0.90	0.98
12-Jul-84	2.0	0.00	0.18	0.00	0.82	0.00	0.64	0.93	1.02
13-Jul-84	2.2	0.00	0.21	0.00	0.77	0.00	0.66	1.01	1.03
14-Jul-84	2.0	0.00	0.21	0.00	0.87	0.00	0.81	1.00	1.07
15-Jul-84	1.8	0.00	0.21	0.00	0.84	0.00	0.83	1.02	1.04
16-Jul-84	1.9	0.00	0.21	0.00	0.80	0.00	0.77	0.98	1.05
17-Jul-84	1.7	0.00	0.21	0.00	0.78	0.00	0.66	0.94	1.04
18-Jul-84	1.8	0.00	0.20	0.00	0.78	0.00	0.68	0.92	0.95
19-Jul-84	2.2	0.00	0.20	0.00	0.80	0.00	0.65	0.92	1.01
20-Jul-84	2.0	0.00	0.20	0.00	0.81	0.00	0.71	1.01	1.04
21-Jul-84	1.9	0.00	0.21	0.00	0.84	0.00	0.78	1.04	1.00
22-Jul-84	1.8	0.00	0.21	0.00	0.82	0.00	0.81	1.03	1.05
23-Jul-84	1.8	0.00	0.19	0.00	0.84	0.00	0.77	0.91	1.05
24-Jul-84	2.0	0.00	0.21	0.00	0.88	0.00	0.72	1.01	1.04
25-Jul-84	1.9	0.00	0.19	0.00	0.79	0.00	0.79	0.97	0.98
26-Jul-84	2.1	0.00	0.19	0.00	0.77	0.00	0.68	0.97	0.99
27-Jul-84	2.0	0.00	0.20	0.00	0.82	0.00	0.74	0.96	0.89
28-Jul-84	1.9	0.05	0.20	0.00	0.84	0.00	0.85	0.96	0.89
29-Jul-84	1.7	0.00	0.19	0.00	0.82	0.00	0.82	0.98	0.94
30-Jul-84	1.9	0.06	0.20	0.00	0.83	0.00	0.72	0.94	0.93
31-Jul-84	2.1	0.15	0.20	0.00	0.80	0.00	0.73	0.93	0.98
maximum	2.7	0.15	0.22	0.00	0.91	0.00	0.85	1.04	1.07
minimum	1.7	0.00	0.18	0.00	0.76	0.00	0.58	0.83	0.88
mean	2.0	0.01	0.20	0.00	0.82	0.00	0.74	0.96	0.99
#data	31	31	31	31	31	31	31	31	31
stan dev	0.2	0.03	0.01	0.00	0.04	0.00	0.07	0.05	0.05

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluoride Residual - lab)

TABLE 3.1 (cont'd)

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

DISINFECTION PROFILE

DECEMBER 1984

DATE	CHLORINE DOSE		AMMONIA DOSE	SULPHUR DIOXIDE DOSE	CHLORINE RESIDUAL			FLUORIDE DOSE	FLUORIDE RESIDUAL
	pre (mg/L)	post	(mg/L)	(mg/L)	plant total	lab free (mg/L)	lab total	(mg/L)	(mg/L)
01-Dec-84	2.0	0.07	0.21	0.00	0.75	0.00	0.59	1.06	1.05
02-Dec-84	2.3	0.00	0.22	0.00	0.85	0.00	0.81	1.05	1.02
03-Dec-84	2.4	0.00	0.22	0.00	0.88	0.00	0.84	1.11	1.09
04-Dec-84	2.3	0.16	0.21	0.00	0.81	0.00	0.79	1.06	1.08
05-Dec-84	2.3	0.15	0.21	0.00	0.72	0.03	0.55	1.01	1.07
06-Dec-84	2.4	0.12	0.21	0.00	0.68	0.03	0.48	1.00	1.03
07-Dec-84	2.0	0.10	0.21	0.00	0.79	0.05	0.60	1.07	1.14
08-Dec-84	1.7	0.00	0.21	0.00	0.86	0.00	0.90	1.12	1.07
09-Dec-84	1.5	0.00	0.22	0.00	0.89	0.00	0.92	1.09	1.03
10-Dec-84	1.7	0.36	0.21	0.00	0.86	0.00	0.63	1.05	1.06
11-Dec-84	1.6	0.27	0.20	0.00	0.84	0.00	0.65	0.98	0.98
12-Dec-84	1.9	0.12	0.21	0.00	0.82	0.00	0.69	1.04	1.06
13-Dec-84	2.0	0.24	0.21	0.00	0.80	0.00	0.71	1.06	1.05
14-Dec-84	2.1	0.00	0.21	0.00	0.80	0.00	0.53	1.06	1.05
15-Dec-84	2.1	0.00	0.21	0.00	0.74	0.00	0.49	1.07	1.05
16-Dec-84	1.8	0.00	0.23	0.00	0.87	0.00	0.64	1.06	1.11
17-Dec-84	1.6	0.00	0.22	0.00	0.82	0.00	0.62	1.05	1.09
18-Dec-84	1.7	0.29	0.22	0.00	0.79	0.00	0.71	1.08	1.08
19-Dec-84	2.0	0.00	0.21	0.00	0.82	0.00	0.80	1.06	1.04
20-Dec-84	1.9	0.00	0.21	0.00	0.81	0.00	0.86	1.04	0.98
21-Dec-84	2.3	0.00	0.21	0.00	0.84	0.00	0.72	1.01	1.02
22-Dec-84	1.9	0.00	0.20	0.00	0.81	0.00	0.95	1.07	1.06
23-Dec-84	2.0	0.00	0.21	0.00	0.83	0.00	0.91	1.03	1.09
24-Dec-84	2.0	0.00	0.21	0.00	0.81	0.00	0.82	1.00	1.09
25-Dec-84						0.01	0.65		
26-Dec-84		0.00	0.21	0.00	0.73			1.06	
27-Dec-84		0.00	0.21	0.00	0.88			1.04	
28-Dec-84		0.00	0.21	0.00	0.84			1.07	
29-Dec-84		0.00	0.21	0.00	0.84			1.06	
30-Dec-84		0.00	0.22	0.00	0.83			1.15	
31-Dec-84		0.00	0.22	0.00	0.79	0.00	0.80	1.13	1.17
maximum	2.4	0.36	0.23	0.00	0.89	0.05	0.95	1.15	1.17
minimum	1.5	0.00	0.20	0.00	0.68	0.00	0.48	0.98	0.98
mean	2.0	0.06	0.21	0.00	0.81	0.00	0.72	1.06	1.06
#data	24	30	30	30	30	26	26	30	25
stan dev	0.3	0.10	0.01	0.00	0.05	0.01	0.13	0.04	0.04

Sources: Chemical doses) Water Works Purification Plant Monthly Report
Cl2 Residual - plant)

Cl2 Residuals - lab) Daily laboratory data sheets
Fluoride Residual - lab)

MINISTRY of the ENVIRONMENT
TRIHALOMETHANE ANALYSIS

	CHCl3	CHBrCl2	CHClBr2	TOTAL THM
02/04/85				
raw	-	-	-	-
treated	21	14	5	40
treated	17	10	4	31
distribution	15	11	4	30
07/05/85				
raw	-	-	-	-
treated	26	13	5	44
treated	23	10	5	38
distribution	18	11	5	34
09/07/85				
raw	2	* -	-	2
treated	21	11	4	36
treated	18	7	2	27
distribution	16	8	3	27
07/08/85				
raw	-	-	-	-
treated	19	11	4	35
treated	9	9	4	2
distribution	18	10	5	33
10/09/85				
raw	-	-	-	-
treated	27	19	5	51
treated	26	13	3	42
distribution	17	11	4	32
01/10/85				
raw	-	-	-	-
treated	6	5	1	12
treated	5	6	1	12
distribution	5	5	1	11
05/11/85				
raw	-	-	-	-
treated	6	7	3	16
treated	4	5	2	11
distribution	5	7	4	16
04/02/86				
raw	-	-	-	-
treated	8	5	3	16
treated	11	8	4	23
distribution	9	7	4	20
03/03/86				
raw	-	-	-	-
treated	8	6	3	17
treated	5	3	2	10
distribution	9	7	4	20
01/04/86				
raw	-	-	-	-
treated	11	7	4	22
treated	8	4	3	15
distribution	10	7	4	21
08/05/86				
raw	-	-	-	-
treated	10	7	4	22
treated	10	5	2	17
distribution	12	8	4	24
09/07/86				
raw	-	-	-	-
treated	13	9	5	27
treated	14	9	5	28
distribution	4	4	2	10

NOTES: CHCl3 - CHLOROFORM THM - TRIHALOMETHANES
CHBrCL2 - BROMOCHLOROMETHANE *-* - not detected
CHClBr2 - CHLORODIBROMOMETHANE

all units: ug/L

ONTARIO DRINKING WATER OBJECTIVE: 350 ug/L TOTAL TRIHALOMETHANES

Table 4.0

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

MINISTRY of the ENVIRONMENT
TRIHALOMETHANE ANALYSIS

	CHCl3	CHBrCl2	CHClBr2	TOTAL THM
11/01/84				
raw	-	-	-	
treated	4	6	-	10
treated	2	1	-	3
distribution	5	7	-	12
07/02/84				
raw	-	-	-	
treated	10	9	-	19
treated	6	6	4	16
06/03/84				
raw	-	-	-	
treated	11	10	5	26
treated	9	7	4	20
distribution	11	10	5	26
04/04/84				
raw	-	-	-	
treated	13	11	5	29
treated	7	7	4	18
distribution	9	8	4	21
01/05/84				
raw	15	11	8	34
treated	11	10	-	21
treated	8	6	-	14
distribution	12	11	-	23
10/07/84				
raw	27	13	4	
treated	11	7	-	
treated	6	4	-	
distribution	9	7	-	
07/08/84				
raw	43	16	4	63
treated	22	8	-	30
treated	8	5	-	13
distribution	11	8	-	19
02/10/84				
raw	-	-	-	-
treated	14	11	4	29
treated	14	8	4	26
distribution	13	11	4	28
06/11/84				
raw	-	-	-	-
treated	18	11	5	34
treated	15	8	4	27
distribution	17	11	5	33
08/01/85				
raw	-	-	-	-
treated	9	9	4	22
treated	9	7	3	19
distribution	18	15	6	39
05/03/85				
raw	-	-	-	-
06/03/85				
treated	13	9	3	25
treated	11	6	2	19
distribution	11	9	4	24

NOTES: CHCl3 - CHLOROFORM THM - TRIHALOMETHANES
CHBrCL2 - BROMODCHLOROMETHANE '-' - not detected
CHClBR2 - CHLORODIBROMOMETHANE

all units: ug/L

ONTARIO DRINKING WATER OBJECTIVE: 350 ug/L TOTAL TRIHALOMETHANES

Table 4.1

HAMILTON WATER TREATMENT PLANT OWSP RESULTS

06/12/87

PARAMETERS	UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23					DETECTION LIMIT	DRINKING WATER OBJ
1,1 DICHLOROETHANE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.10	10.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
1,1 DICHLOROETHYLENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.10	.300
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
1,2 DICHLOROBENZENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.05	400.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
1,2 DICHLOROETHANE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.05	NONE
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
1,2 DICHLOROPROPANE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.05	6.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
1,3 DICHLOROBENZENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.10	400.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
1,4 DICHLOROBENZENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.01	400.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
11, TRICHLOROETHANE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.02	NONE
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
12 TRICHLOROETHANE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.05	6.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
122 T-CHLOROETHANE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.05	1.700
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
123 TRICHLOROBENZENE	NG/L	R	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W					5.000	10000.000
		T	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W						
1234 T-CHLOROBENZENE	NG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W					1.000	38000.000
		T	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W						

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS

06/12/07

PARAMETERS	UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
1255 T-CHLOROBENZENE	NG/L	R	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000	15000.000
		T	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U		
124 TRICHLOROBENZENE	NG/L	R	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000	NONE
		T	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U		
1245 T-CHLOROBENZENE	NG/L	R	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000	38000.000
		T	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U	1.000 <U		
135 TRICHLOROBENZENE	NG/L	R	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000	10000.000
		T	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U		
2,4 D PROPIONIC ACID	NG/L	R			100.00 <U						100.00	NONE
		T			100.00 <U							
2,4,5-T	NG/L	R			50.000 <U						50.00	NONE
		T			50.000 <U							
2,4-D	NG/L	R			100.00 <U						100.00	110000.000
		T			100.00 <U							
234 TRICHLOROPHENOL	NG/L	R			100.00 <U						100	NONE
		T			100.00 <U							
2345 T-CHLOROPHENOL	NG/L	R			50.000 <U						20	NONE
		T			50.000 <U							
2356 T-CHLOROPHENOL	NG/L	R			50.000 <U						10	NONE
		T			50.000 <U							
236 TRICHLOROTOLUENE	NG/L	R	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000	NONE
		T	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U	5.000 <U		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS

06/12/87

PARAMETERS	UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
245 TRICHLOROTOLUENE	NG/L	R	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000	10000.000
		T	5.000 <W	5.000 <W	5.000 <W	6.000 <T	5.000 <W	5.000 <W	5.000 <W	5.000 <W		
245-TRICHLOROPHENOL	NG/L	R			50.000 <W						100	NONE
		T			50.000 <W							
246-TRICHLOROPHENOL	NG/L	R			50.000 <W						20	10000.000
		T			50.000 <W							
24DCHLRPHENOXYBUTYRC	NG/L	R			200.00 <W						200.00	NONE
		T			200.00 <W							
26A TRICHLOROTOLUENE	NG/L	R	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000	NONE
		T	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W		
ALACHLOR	NG/L	R			500.00 <W		500.00 <W	500.00 <W	500.00 <W	500.00 <W	500	NONE
		T			500.00 <W		500.00 <W	500.00 <W	500.00 <W	500.00 <W		
ALDRIN	NG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000	1400.000
		T	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W		
ALKALINITY	MG/L-CAC	R	97.400	96.200	97.600	103.60	98.900	99.10	101.00	104.20	0.2	NONE
		T	92.800	92.000	91.800	96.600	94.700	93.600	96.200	100.10		
ALPHA BHC	NG/L	R	2.000 <T	3.000 <T	2.000 <T	3.000 <T	2.000 <T	2.000 <T	2.000 <T	6.000 <T	1.000	700.000
		T	3.000 <T	3.000 <T	2.000 <T	3.000 <T	2.000 <T	2.000 <T	2.000 <T	3.000 <T		
ALPHA CHLORDANE	NG/L	R	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000	1400.000
		T	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W		
ALUMINUM	MG/L-AL	R	.093	.036	.047	.029	2.000	.025	.032	.069	0.01	.100
		T	.130	.092	.190	.110	.076	.053	.078	.120		
AMETRINE	NG/L	R			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W	50.00	NONE
		T			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT DWSP RESULTS

06/12/87

PARAMETERS	UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
CHLORDANE	NG/L	R			.000 IS						200	NONE
		T			.000 IS							
AMMONIUM TOTAL	MG/L-N	R	.152	.022	.036	.020	.002 <T	.006 <T	.018	.048	0.002	NONE
		T	.076	.082	.114	.036	.068	.068	.140	.060		
ARSENIC	MG/L-AS	R	.001	.001 <	.001 <	.000	.001	.001 <	.001 <	.001 <	0.001	.050
		T	.001	.001 <	.001 <	.001	.001 <	.001 <	.001 <	.001 <		
ATRATONE	NG/L	R			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W	50.00	NONE
		T			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W		
ATRAZINE	NG/L	R			50.000 <W		50.000 <W	370.00 <T	50.000 <W	50.000 <W	50.00	46000.000
		T			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W		
BARIUM	MG/L-BA	R	.018	.018	.027	.021	.035	.021	.021	.022	0.001	1.000
		T	.019	.018	.026	.021	.020	.020	.021	.021		
BENOMYL	NG/L	R			.000 IS						200	NONE
		T			.000 IS							
BENZENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.05	10.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		
BERYLLIUM	MG/L-BE	R	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	0.005	NONE
		T	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <		
BETA BHC	NG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000	700.000
		T	1.000 <T	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W		
BIDEX	NG/L	R			100.00 <W		100.00 <W	5450.0	100.00 <W	100.00 <W	100.00	NONE
		T			100.00 <W		100.00 <W	100.00 <W	100.00 <W	100.00 <W		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS 06/12/87

RAMETERS		UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
RON	MG/L-BO		R	.020	.030	.030	.040	.030	.020	.040	.030	0.005	5.000
			T	.030	.030	.040	.050	.030	.030	.030	.030		
OMOFORM	UG/L		R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.2	700.000
			T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		
X	NG/L		R			.000 IS						200	NONE
			T			.000 IS							
DMIUM	UG/L-CD		R	.200 <	.200 <	.300 <	.300 <	.300 <	.300 <	.300 <	.300 <	2.000	5.000
			T	.200 <	.200 <	.300 <	.300 <	.300 <	.300 <	.300 <	.300 <		
LCIUM	MG/L-CA		R	39.500	39.000	39.400	40.200	40.000	39.700	40.800	41.900	0.2	NONE
			T	40.000	38.600	39.700	39.500	39.800	39.700	41.300	41.200		
RBOFURAN	NG/L		R			.000 IS						200	NONE
			T			.000 IS							
RBON TETRACHLORIDE	UG/L		R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.2	3.000
			T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		
LORIDE	MG/L-CL		R	26.400	25.000	24.000	25.600					0.5	250.000
			T	28.000	27.200	26.000	27.200						
LORIDE	MG/L-CL-		R					25.000	25.000	27.500	27.000	0.5	250.000
			T					26.000	26.500	29.500	29.500		
LOROBENZENE	UG/L		R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.1	100.000
			T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		
LORODIBROMOMETHANE	UG/L-		R	11.000	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.1	353.000
			T	.000 <W	12.000	5.000	2.000	5.000	4.000	3.000	5.000		
LOROFORM	UG/L		R	9.000	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.1	350.000
			T	.000 <W	9.000	13.000	8.000	7.000	8.000	7.000	14.000		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS

06/12/87

PARAMETERS		UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
CHROMIUM	MG/L-CR		R	.002	.002	.001 <	.001 <	.005	.001	.001 <	.001 <	.5UG/L	50.000
			T	.003	.002	.001 <	.001 <	.001	.001 <	.001	.001 <		
CICP	MG/L		R			.000	IS					200	NONE
			T			.000	IS						
CL4 BIPENYL	UG/L		R		1.000 <W							1.000	NONE
			T		1.000 <W								
COBALT	MG/L-CO		R	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.5UG/L	NONE
			T	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <		
COLOUR	HZU		R	5.000	4.000	4.000	1.000 <T	4.500	2.500 <T	1.000 <T	3.500	0.5	5.000
			T	1.000 <T	2.000	1.500 <T	1.500 <T	1.000 <T	1.500 <T	1.000 <T	2.000 <T		
CONDUCTIVITY	UMHO/CM		R	343.00	327.00	315.00	339.00	335.00	329.00	331.00	352.00	1.0	NONE
			T	344.00	332.00	320.00	338.00	336.00	333.00	336.00	357.00		
COPPER	MG/L-CU		R	.004	.018	.002	.001	.007	.005	.001	.002	.5UG/L	1.000
			T	.027	.005	.001	.001	.016	.001	.001	.001		
CYANIDE	MG/L-CN		R	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W	0.001	.400
			T	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W		
DDD	MG/L		R	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000	NONE
			T	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W		
DI-N-BUTYL PHTHALATE	UG/L		R		1.000 <W							1.000	NONE
			T		1.000 <W								
DIALLATE	MG/L		R			.000	IS					200	NONE
			T			.000	IS						

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS 06/12/87

PARAMETERS		UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23					DETECTION LIMIT	DRINKING WATER OBJ
DIAZINON		NG/L	R			20.000 <W										50	20000.000
			T			20.000 <W											
DICAMBA		NG/L	R			100.00 <W										100.00	NONE
			T			100.00 <W											
DICHLOROBROMOMETHANE		UG/L	R	8.000	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.05	700.000
			T	.000 <W	8.000	8.000	8.000	7.000	7.000	7.000	10.000						
DICHLOROVOS		NG/L	R			20.000 <W										50	NONE
			T			20.000 <W											
DIELDRIN		NG/L	R	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W					2.000	1400.000
			T	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W						
DIPHENYL ETHER		UG/L	R		1.000 <W											1.000	NONE
			T		1.000 <W												
DURSBAN		NG/L	R			20.000 <W										50	NONE
			T			20.000 <W											
ENDRIN		NG/L	R	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W					4.000	400.000
			T	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W						
EPTAM		NG/L	R			.000 IS										200	NONE
			T			.000 IS											
ETHION		NG/L	R			20.000 <W										50	NONE
			T			20.000 <W											
ETHLYENE DIBROMIDE		UG/L	R			.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.05	NONE
			T			.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
ETHYLBENZENE		UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.05	1400.000
			T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS

06/12/87

PARAMETERS	UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
FECAL COLIFORM MF	CT/100ML	R	5.000	.000	.000	1.000	.000 OP	.000	.000	.000		.000
		T										
FLO CHLORINE (COMB)	MG/L-CL	R	.860	.900	.730	.750	.870	.970	.850	.800		NONE
		T										
FLO CHLORINE (TOTAL)	MG/L-CL	R	.860	.980	.730	.750	.870	.970	.850	.800		NONE
		T										
FLO PH		R	7.650	7.250	7.900	7.700		7.730	7.930	7.800		NONE
		T	7.300	7.300	7.300	7.500		7.350	7.550	7.290		
FLO TEMPERATURE	DEG.C	R	2.000	1.000	11.000	7.000	4.000	2.000	2.000	4.000		NONE
		T	2.000	1.000	11.000	7.000	4.000	2.000	2.000	4.000		
FLO TURBIDITY	FTU	R	2.700	1.000	1.400	1.600	1.500	1.800	1.400	2.300		NONE
		T	.370	.250	.220	.240	.520	.240	.240	.350		
FLUORANTHENE	UG/L	R		1.000 <W							1.000	NONE
		T		1.000 <W								
FLUORIDE	MG/L-F	R	.150	.140	.150	.140	.150	.140	.140	.190	0.01	2.400
		T	.920	.920	.950	.890	.870	.700	.430	.200		
GAMMA CHLORDANE	NG/L	R	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000	7700.000
		T	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W		
GUTHION	NG/L	R			.000 NP						50	NONE
		T			.000 NP							
HARDNESS	MG/L-CAC	R	134.40	133.00	133.00	135.00	133.00	133.00	136.50	139.50		500.000
		T	135.30	132.00	133.00	135.00	132.50	133.00	138.00	138.00		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT DWSP RESULTS

06/12/87

PARAMETERS		UNITS	SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
HCB	MG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000	NONE
		T	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W		
HEPTACHLOR	MG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000	3000.000
		T	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W		
HEPTACHLOR EPOXIDE	MG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000	6000.000
		T	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W		
HEXACHLOROBUTADIENE	MG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000	4500.000
		T	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W		
HEXACHLOROETHANE	MG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000	19000.000
		T	1.000 <W	1.000 <W	1.000 <W	1.000 <T	1.000 <W	7.000 <T	1.000 <W	4.000 <T		
HEXACHLOROPROPENE	UG/L	R		1.000 <W							1.000	NONE
		T		1.000 <W								
IPC	MG/L	R			.000 IS						200	NONE
		T			.000 IS							
IRON	MG/L-FE	R	.008	.019	.033	.043	4.000	.032	.033	.069	0.02	.300
		T	.120	.006	.008	.009	.007	.006	.009	.024		
LEAD	MG/L-PB	R	.003 <	.003 <	.003 <	.003 <	.010	.003 <	.003 <	.003 <	0.005	.050
		T	.003 <	.003 <	.003 <	.003 <	.004	.003 <	.003 <	.003 <		
LINDANE	NG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <T	1.000 <W	1.000 <W	1.000 <W	2.000 <T	1.00	6000.000
		T	1.000 <W	1.000 <W	1.000 <W	1.000 <T	1.000 <W	1.000 <W	1.000 <T	2.000 <T		
M-XYLENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.1	620.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		
MAGNESIUM	MG/L-MG	R	8.700	8.600	8.350	8.450	8.000	8.250	8.400	8.500	0.1	NONE
		T	8.600	8.600	8.200	8.400	8.100	8.200	8.500	8.500		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS

06/12/87

PARAMETERS		UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23						DETECTION LIMIT	DRINKING WATER OBJ
MALATHION		NG/L	R			20.000 <W											50	NONE
			T			20.000 <W												
MANGANESE		MG/L-MN	R	.002	.003	.002	.005	.140	.003	.004	.005						.5UG/L	.050
			T	.010	.001	.001	.001	.001 <W	.001 <W	.001 <W	.001							
MERCURY		UG/L-HG	R	.010 <	.020	.010 <	.010 <	.030	.010	.020	.010 <						0.010	1.000
			T	.010 <	.010	.010 <	.010 <	.010 <	.010	.010	.010 <							
METHOXYCHLOR		NG/L	R	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W						5.000	200000.000
			T	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W							
METHYL PARATHION		NG/L	R			20.000 <W											50	14000.000
			T			20.000 <W												
METHYL PHENANTHRENE		UG/L	R		1.000 <W												1.000	NONE
			T		1.000 <W													
METHYLENE CHLORIDE		UG/L	R			.000 CS	.000 <W	.000 <W	.000 <W	.000 <W	.000 CS						0.5	40.000
			T	.000 <W		.000 CS	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W							
METHYLTRITION		NG/L	R			20.000 <W											50	NONE
			T			20.000 <W												
METOLACHLOR		NG/L	R			500.00 <W		500.00 <W	500.00 <W	500.00 <W	500.00 <W						500	NONE
			T			500.00 <W		500.00 <W	500.00 <W	500.00 <W	500.00 <W							
MEVINPHOS		NG/L	R			20.000 <W											50	NONE
			T			20.000 <W												
MIREX		NG/L	R	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W						5.000	NONE
			T	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W							

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT DWSP RESULTS

06/12/87

RAMETERS		UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23					DETECTION LIMIT	DRINKING WATER OBJ
LYBDENUM	MG/L-MB		R	.001	.001 <	.002	.001 <W	.001 <W	.001	.001	.001					.5UG/L	NONE
			T	.001	.001 <	.001	.001	.001	.001	.001	.001						
CL2METHYLENECL5ANA	UG/L		R		1.000 <W											1.000	NONE
			T		1.000 <W												
PHTHALENE	UG/L		R		1.000 <W											1.000	NONE
			T		1.000 <W												
ICKEL	MG/L-NI		R	.001	.001	.002	.002 <	.004	.002 <	.002	.002					0.002	NONE
			T	.002	.002	.002 <	.002 <	.002 <	.002 <	.002 <	.002 <						
ITRITE	MG/L-N		R	.001 <T	.003	.010	.019	.001 <T	.001 <T	.005	.008					0.001	1.000
			T	.005	.001 <T	.003 <T	.001 <T	.001 <T	.001 <T	.001 <T	.002 <T						
ITROGEN TOT KJELD	MG/L-N		R	.270	.250	.130 UCR	.120	.350 <T	.190	.220	.200					0.02	NONE
			T	.260	.280	.260 UCR	.090 <T	.150	.250	.250	.100						
-XTLENE	UG/L		R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.05	620.000
			T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
CTACHLOROSTTRENE	NG/L		R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W					1.000	NONE
			T	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W						
PDOT	NG/L		R	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W					5.000	60000.000
			T	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W						
XTCHLORDANE	NG/L		R	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W					2.000	NONE
			T	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W						
-XTLENE	UG/L		R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W					0.1	620.000
			T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W						
/A BOTTLE	0=ABSENT		R	.000	.000	.000	.000	.000	.000	.000	.000						.000
			T														

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS

06/12/87

AMETERS		UNITS	SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
ATHION	NG/L	R			20.000 <W						50	70000.000
		T			20.000 <W							
	NG/L	R	20.000 <W	20.000 <W	20.000 <W	20.000 <W	20.000 <W	20.000 <W	20.000 <W	20.000 <W	20.000	6000.000
		T	20.000 <W	20.000 <W	20.000 <W	20.000 <W	20.000 <W	20.000 <W	20.000 <W	20.000 <W		
TACHLOROBENZENE	NG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000	74000.000
		T	1.000 <W	1.000 <W	1.000 <W	3.000 <T	1.000 <W	1.000 <W	1.000 <W	1.000 <W		
TACHLOROBUTADIENE	UG/L	R		1.000 <W							1.000	NONE
		T		1.000 <W								
TACHLOROPHENOL	NG/L	R			50.000 <W						10	10000.000
		T			50.000 <W							
TACHLOROPROPANE	UG/L	R		1.000 <W							1.000	NONE
		T		1.000 <W								
TACHLOROPROPENE	UG/L	R		1.000 <W							1.000	NONE
		T		1.000 <W								
		R	8.140	8.180	8.360	8.390	8.210	8.170	8.200	8.320		8.500
		T	7.650	7.880	8.200	8.370	8.180	7.890	7.950	8.210		
ENOLICS	UG/L	R						.400 <T	.200 <W	.600 <T	0.2	NONE
		T						.200 <T	.200 <W	.400 <T		
ORATE	NG/L	R			20.000 <W						50	NONE
		T			20.000 <W							
OSPHORUS FIL REACT	MG/L-P	R	.014	.005	.003	.004	.011	.005	.001 <T	.006	.5UG/L	NONE
		T	.008	.008	.002	.002 <T	.002 <T	.002	.001 <T	.003		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT DWSP RESULTS

06/12/87

ARAMETERS	UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
HOSPHORUS TOTAL	MG/L-P	R	.014	.011	.002 UCR	.015	.330	.009 <T	.015	.021	0.002	NONE
		T	.011	.012	.002 UCR	.008 <T	.006 <T	.002 <T	.005 <T	.006 <T		
ICHLORAM	MG/L	R			.000 NP						100.00	NONE
		T			.000 NP							
PDE	MG/L	R	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000	30000.000
		T	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W	1.000 <W		
PDOT	MG/L	R	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000	30000.000
		T	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W	5.000 <W		
ROMETONE	MG/L	R			50.000 <W		50.000 <W	1460.0	50.000 <W	50.000 <W	50.00	NONE
		T			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W		
ROMETRYNE	MG/L	R			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W	50.00	NONE
		T			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W		
ROPAZINE	MG/L	R			50.000 <W		50.000 <W	130.00 <T	50.000 <W	50.000 <W	50.00	NONE
		T			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W		
ROPOXUR	MG/L	R			.000 IS						200	NONE
		T			.000 IS							
YRENE	UG/L	R		1.000 <W							1.000	NONE
		T		1.000 <W								
ELOAN	MG/L	R			20.000 <W						50	NONE
		T			20.000 <W							
ONNEL	MG/L	R			20.000 <W						50	NONE
		T			20.000 <W							
ELENIUM	MG/L-SE	R	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	0.001	.010
		T	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <	.001 <		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT DWSP RESULTS

06/12/87

AMETERS	UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
RACHLOROBUTANE	UG/L	R		1.000 <W							1.000	NONE
		T		1.000 <W								
DDAN I	NG/L	R	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000	740000.000
		T	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W	2.000 <W		
DDAN II	NG/L	R	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000	74000.000
		T	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W		
DDAN SULPHATE	NG/L	R	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000	NONE
		T	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W	4.000 <W		
	MG/L-SN	R			.000 NP	.000 NP	.000 NP	.000 NP	.000 NP	.000 NP		NONE
		T			.000 NP	.000 NP	.000 NP	.000 NP	.000 NP	.000 NP		
UENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.05	14300.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		
AL COLIFORM MF	CT/100ML	R	92.000	1.000	13.000 A3C	33.000 A3C	66.000	7.000	2.000	2.000 A3C		NONE
		T	.000	.000	.000	.000	.000	.000	.000	.000		
AL NITRATES	MG/L-N	R	.450	.410	.295	.430	.650	.435	.425	.440	0.02	10.000
		T	.455	.410	.285	.460	.655	.440	.440	.425		
AL SOLIDS	MG/L	R	223.00 CRO	213.00 CRO	207.00	206.00	405.00	214.00 CRO	202.00	200.00	2.0	500.000
		T	224.00 CRO	216.00 CRO	202.00	220.00 CRO	218.00 CRO	216.00 CRO	218.00 CRO	232.00 CRO		
L TRIHALOMETHANES	UG/L	R	28.000	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.2	350.000
		T	.000 <W	29.000	26.000	18.000	19.000	19.000	17.000	29.000		
APHENE	NG/L	R			.000 NP	.000 NP	.000 NP	.000 NP	.000 NP	.000 NP		NONE
		T			.000 NP	.000 NP	.000 NP	.000 NP	.000 NP	.000 NP		
CHLOROETHYLENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.1	30.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS

06/12/87

ARAMETERS	UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
ENCOR	MG/L	R			100.00 <W		100.00 <W	100.00 <W	100.00 <W	100.00 <W	100.00	NONE
		T			100.00 <W		100.00 <W	100.00 <W	100.00 <W	100.00 <W		
EVIN	MG/L	R			.000 IS						200	NONE
		T			.000 IS							
ILVEX	MG/L	R			50.000 <W						50.00	20000.000
		T			50.000 <W							
IMAZINE	MG/L	R			50.000 <W		50.000 <W	860.00	50.000 <W	50.000 <W	50.00	NONE
		T			50.000 <W		50.000 <W	50.000 <W	50.000 <W	50.000 <W		
ODIUM	MG/L-NA	R	14.000	13.500	12.500	12.500	12.700	12.600	14.700	14.500	0.2	NONE
		T	13.500	13.500	12.200	12.500	12.600	12.400	14.700	14.700		
TANDRD PLATE CNT MF	CT/ML	R	73.000	10.000	.000 AW	1400.0	.000 AW	45.000	32.000	101.00		NONE
		T	.000	.000	.000 AW	4.000	.000 AW	4.000	.000	4.000		
TRONTIUM	MG/L-SR	R	.160	.170	.190	.170	.170	.170	.170	.180	0.001	NONE
		T	.160	.170	.180	.170	.160	.170	.170	.180		
UTAN	MG/L	R			.000 IS						200	NONE
		T			.000 IS							
COLIFORM BCKGRD MF	CT/100ML	R	242.00	4.000	610.00	380.00	404.00	33.000	8.000	350.00		NONE
		T	.000	.000	.000	.000	.000	.000	.000	1.000		
-CHLOROETHYLENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.05	10.000
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		
1,2DICHLOROETHYLENE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.1	NONE
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		

Table 4.1 (cont'd)

HAMILTON WATER TREATMENT PLANT OWSP RESULTS

06/12/87

METERS	UNITS		SAMPLE DATE 86/02/02	86/03/04	86/10/28	86/11/24	86/12/15	87/01/26	87/02/23	87/03/23	DETECTION LIMIT	DRINKING WATER OBJ
LUOROCHLOROTOLUE	UG/L	R	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	0.1	NONE
		T	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W	.000 <W		
IDITY	FTU	R	3.300	.760 <T	1.020	1.920	59.000	1.730	1.600	2.900	0.02	1.000
		T	.220 <T	.240 <T	.370 <T	.240	.310	.570	.100	.520		
IUM	MG/L-U	R	.002 <	.002 <							0.1 UG/L	.020
		T	.002 <	.002 <								
IUM	UG/L-U	R			.300	.410	.450	.460	.340	.330	0.1	50.0
		T			.330	.400	.380	.450	.320	.370		
DIUM	MG/L-V	R	.001 <	.001 <	.001 <W	.001 <W	.003	.001 <W	.001 <W	.001 <W	.5UG/L	NONE
		T	.001 <	.001 <	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W	.001 <W		
	MG/L-ZN	R	.003	.005	.002	.001 <W	.031	.002	.002	.002	.5UG/L	5.000
		T	.005	.006	.001	.001 <W	.005	.001	.001	.001 <W		

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

SUMMARY OF

REGIONAL LABORATORY WATER ANALYSIS DATA

	RAW WATER								TREATED WATER						
	NH3	pH	ALK	TOTAL HARD.	Cl-	F-	TURB	TURB WW	Cl2 free	Cl2 total	TURB*	F-	pH	ALK	NH3
	(mg/L)			(mg/L as CaCO3)	(mg/L)	(mg/L)	(FTU)	(FTU)	(mg/L)		(FTU)	(mg/L)		(mg/L as CaCO3)	(mg/L)
APRIL 1984															
maximum	0.13	7.65	98	141	29.1	0.27	18.0	13.5	0.20	0.83	0.70	1.12	7.40	90	0.19
minimum	0.01	6.70	80	135	25.5	0.12	1.3	1.9	0.00	0.53	0.24	0.97	6.05	77	0.06
mean	0.05	7.35	92	138	27.4	0.19	3.8	4.8	0.01	0.71	0.39	1.04	6.81	83	0.12
#data	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
stan dev	0.03	0.26	4	2	1.1	0.03	3.7	2.5	0.04	0.07	0.12	0.03	0.23	3	0.03
JULY 1984															
maximum	0.05	7.50	99	144	29.0	0.27	2.5	3.0	0.00	0.85	0.69	1.07	7.03	89	0.15
minimum	0.01	7.10	87	125	25.5	0.17	1.3	1.8	0.00	0.58	0.35	0.88	6.75	80	0.06
mean	0.02	7.30	93	136	27.6	0.21	1.8	2.3	0.00	0.74	0.51	0.99	6.86	86	0.11
#data	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
stan dev	0.01	0.11	2	4	0.9	0.02	0.3	0.3	0.00	0.07	0.10	0.05	0.06	2	0.02
DECEMBER 1984															
maximum	0.05	7.43	99	152	26.8	0.27	20.0	16.5	0.05	0.95	0.39	1.17	6.93	88	0.17
minimum	0.01	7.15	91	131	25.0	0.14	0.8	1.5	0.00	0.48	0.13	0.98	6.58	83	0.03
mean	0.03	7.30	94	135	25.7	0.21	3.5	4.4	.00	0.72	0.27	1.06	6.76	85	0.10
#data	26	25	25	25	25	25	24	26	26	26	25	25	25	25	26
stan dev	0.01	0.07	2	4	0.5	0.03	4.9	4.1	0.01	0.13	0.06	0.04	0.09	1	0.04
APRIL 1985															
maximum	0.26	7.82	99	140	26.7	0.34	33.0		0.00	0.84	0.90	1.13	7.28	99	0.19
minimum	0.01	7.45	90	135	24.2	0.15	0.7		0.00	0.52	0.20	0.95	6.93	85	0.06
mean	0.04	7.56	95	137	25.7	0.21	4.1		0.00	0.72	0.36	1.04	7.14	88	0.11
#data	27	27	27	27	27	27	27		27	26	27	27	27	27	27
stan dev	0.05	0.11	2	1	0.6	0.04	6.0		0.00	0.09	0.13	0.05	0.08	3	0.03
JULY 1985															
maximum	0.05	7.95	97	136	27.5	0.26	3.8		0.02	1.03	0.51	1.60	7.45	93	0.19
minimum	0.01	7.45	93	124	24.0	0.08	1.2		0.00	0.59	0.20	0.86	7.10	87	0.13
mean	0.02	7.71	95	129	25.1	0.18	2.6		.00	0.80	0.34	1.02	7.28	90	0.16
#data	31	31	31	31	31	31	31		31	31	29	31	31	31	31
stan dev	0.01	0.13	1	3	0.8	0.04	0.8		0.01	0.11	0.09	0.14	0.08	1	0.02
DECEMBER 1985															
maximum	0.06	7.85	102	126	27.5	0.24	2.2		0.47	0.90	0.78	1.08	7.70	96	0.18
minimum	0.01	7.10	95	122	23.0	0.15	0.5		0.00	0.60	0.13	0.89	7.10	90	0.02
mean	0.02	7.63	99	125	24.0	0.19	0.9		0.02	0.78	0.25	0.99	7.41	93	0.12
#data	24	24	24	24	24	24	22		24	24	24	24	24	24	24
stan dev	0.01	0.21	2	1	0.9	0.02	0.4		0.09	0.08	0.13	0.04	0.20	2	0.04
APRIL 1986															
maximum	0.23	8.03	102	150	32.5	0.26	2.4		0.01	0.88	0.50	1.04	7.65	96	0.16
minimum	0.01	7.40	98	124	23.0	0.14	0.6		0.00	0.44	0.18	0.18	7.30	90	0.07
mean	0.05	7.77	100	130	25.8	0.19	1.0		.00	0.74	0.32	0.86	7.50	93	0.12
#data	26	26	26	26	26	26	26		26	26	26	26	26	26	26
stan dev	0.04	0.16	1	6	1.6	0.03	0.3		.00	0.09	0.08	0.27	0.09	2	0.02
JULY 1986															
maximum	0.07	7.90	99	137	25.0	0.27	1.9		0.09	0.78	0.78	1.15	7.60	99	1.10
minimum	0.01	7.35	87	130	23.0	0.02	0.1		0.00	0.26	0.24	0.31	7.20	85	0.03
mean	0.03	7.70	94	133	24.2	0.18	1.1		.00	0.58	0.46	1.00	7.41	90	0.16
#data	31	31	31	31	31	31	31		31	31	31	26	31	31	31
stan dev	0.02	0.17	2	2	0.6	0.06	0.4		0.02	0.14	0.14	0.15	0.10	2	0.19
DECEMBER 1986															
maximum	0.06	7.88	133	138	26.0	0.22	9.3		0.08	0.96	1.27	1.02	7.49	93	1.00
minimum	0.01	7.60	92	128	22.5	0.14	0.8		0.00	0.54	0.22	0.86	7.10	88	0.06
mean	0.03	7.74	97	133	24.0	0.18	3.4		.00	0.78	0.47	0.95	7.33	91	0.16
#data	19	19	19	19	19	19	19		20	20	20	20	20	20	20
stan dev	0.02	0.09	9	3	0.8	0.02	2.6		0.02	0.10	0.30	0.04	0.10	1	0.21

NOTE: TURB WW = TURBIDITY MEASURED AT THE WATER PLANT
TURB = TURBIDITY MEASURED AT THE LAB.
TURB* = TURBIDITY MEASURED AT PLANT IN 1984, AT LAB IN 1985 & 1986.

TABLE 6.0

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

BACTERIOLOGICAL TESTING
1986

	RAW WATER												TREATED WATER								
	TOTAL COLIFORMS (#/100ml)						FECAL COLIFORMS (#/100ml)						TOTAL PLATE COUNT (#/ml)						PRESENCE-ABSENCE TEST		
	No. of samples	0	1-5	6-100	101-5000	>5000	No. of samples	0	1-5	6-10	11-500	>500	No. of samples	0	1-5	6-10	11-500	>500	No. of samples	No. confirm tests **	No. Positive
1986																					
APRIL	84	33	29	22	0	0	84	62	21	1	0	0	92	25	53	4	10	0	189	17	0
JULY	90	10	21	54	5	0	84	30	40	4	10	0	120	51	61	3	5	0	205	13	0
DECEMBER	66	8	19	33	6	0	66	21	33	5	7	0	54	29	23	1	1	0	128	22	0
1985																					
APRIL	88	23	37	23	5	0	88	58	23	3	4	0	98	52	33	4	9	0	190	38	0
JULY	97	31	49	15	2	0	97	64	27	1	5	0	117	78	29	4	6	0	208	14	0
DECEMBER	69	8	10	48	3	0	63	30	29	2	2	0	68	32	27	3	6	0	157	12	0
1984																					
APRIL	93	4	26	58	5	0	93	34	45	4	10	0	86	49	32	3	2	0	194	22	0
JULY	108	36	63	9	0	0	107	77	29	0	1	0	91	56	33	2	0	0	208	35	0
DECEMBER	72	2	17	52	1	0	72	22	36	5	9	0	51	36	14	1	0	0	165	8	0

Notes: Total Plate Count is equivalent to Standard Plate Count.
** - number of samples on which one or more confirmatory tests were performed.
P-A confirmatory tests - Mannitol Salt Agar test performed if sample becomes acidic,
complete set of confirmatory tests performed if gas produced in the P-A bottle.

TABLE 7.0

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH WATER TREATMENT PLANT

ONTARIO DRINKING WATER OBJECTIVES EXCEEDENCE SUMMARY
(Health-related parameters)

DATE	PARAMETER	MEASURED CONCENTRATION	OBJECTIVE LIMIT	ANALYSIS BY
DECEMBER 3, 1986	Turbidity	1.27 NTU	1 NTU	Regional Lab.
FEBRUARY 2, 1986	Aluminum	0.130 mg/L	0.10 mg/L	*MOE (DWSP)
OCTOBER 28, 1986	Aluminum	0.190 mg/L	0.10 mg/L	MOE (DWSP)
NOVEMBER 24, 1986	Aluminum	0.110 mg/L	0.10 mg/L	MOE (DWSP)

Note: Of the health-related Ontario Drinking Water Objectives, only turbidity and bacteriological quality are measured by the Regional Laboratory.

The MOE analyzed 5 sets of samples as part of DWSP in 1986 and reported no exceedence of health-related parameters in treated water samples with the exception of aluminum. 3 out of the 5 samples contained >0.10 mg/L aluminum.

APPENDIX B

JAR TESTING RESULTS

JAR TESTING RESULTS

Jar tests to evaluate 2 primary coagulants and three flocculate aids were performed at the water plant on February 26, 1988. The test were set up and run in the Low Lift station to eliminate transportation and aging of the water samples.

METHOD

The procedure followed for the jar tests was as follows:

1. Measure and pour 1000 ml raw water samples into the rectangular baffled jars.
2. Mix slowly while adding chlorine equal to the plant pre-chlorine dose.
3. Increase paddle speed to 100 RPM and add coagulant. If using a flocculation aid reduce air speed to 80 RPM while adding, then return speed to 100 RPM.
4. Flash mix at 100 RPM for 2 minutes.
5. Reduce speed to 30 RPM for 20 minutes, then reduce to 20 RPM for 5 minutes. Observe floc formation.
6. Allow to settle for 30 minute and observe.
7. Decant supernatant and measure turbidity and pH.
8. Filter remaining supernatant through a Whatman 41 filter. Measure turbidity and pH of the filtrate on site. Return filtrate samples to the laboratory for aluminum analysis.

RESULTS

The following are the results of these jar tests:

JAR TEST RESULTS
26 February 1988

RAW WATER:

Turbidity	0.60 NTU
pH	7.9
Temperature	3.8 C
Aluminum	0.02 mg/L

Pre-chlorine dose: 1.4 mg/L

Test #1

Sample	Chemical	Dose (mg/L)	Observations: Floc	Settling	Supernatant Turb. (NTU)	Supernatant pH	Filtrate Turb. (NTU)	Filtrate pH	Al. (mg/L)
1-1	Alum	0			0.58	7.90	0.34	7.90	0.02
1-2	Alum	2	no floc visible		0.41	7.70	0.30	7.80	0.28
1-3	Alum	5	very fine floc after 10 min.	hard to see	0.46	7.75	0.26	7.60	0.42
1-4	Alum	10	small floc after 10 min.	moderate	0.38	7.52	0.23	7.25	0.37
1-5	Alum	15	small floc after 5 min.	faster	0.30	7.45	0.34	7.40	0.56
1-6	Alum	20	small floc after 5 min.	faster	0.60	7.30	0.26	7.49	0.48

Test #2

Sample	Chemical	Dose (mg/L)	Observations: Floc	Settling	Supernatant Turb. (NTU)	Supernatant pH	Filtrate Turb. (NTU)	Filtrate pH	Al. (mg/L)
2-1	PAC	0.0	(		0.56	7.9	0.32	7.75	0.03
2-2	PAC	0.2	(		0.54	8.0	0.33	7.90	0.06
2-3	PAC	0.4	(no visible floc in any sample		0.58	8.0	0.35	7.90	0.08
2-4	PAC	0.6	(		0.60	8.1	0.33	7.90	0.07
2-5	PAC	0.8	(		0.61	7.8	0.32	8.10	0.11
2-6	PAC	1.0	(		0.53	8.1	0.33	8.00	0.15

Test #3

Sample	Chemical	Dose (mg/L)	Observations: Floc	Settling	Supernatant Turb. (NTU)	Supernatant pH	Filtrate Turb. (NTU)	Filtrate pH	Al. (mg/L)
3-1	Alum	5	fine floc after 5 min.	(same	0.42	7.75	0.27	8.00	0.47
	Chargepac 8	0.5		(as					
3-2	Alum	5	small floc after 5 min.	(w/o	0.40	7.50	0.17	7.90	0.40
	Percol 24	0.5		(polymer					
3-3	Alum	5	small floc after 5 min.	(	0.42	7.70	0.23	7.70	0.34
	Alchem 8103	0.5							
3-4	PAC	1	(		0.50	7.45	0.33	7.50	0.10
	Chargepac 8	0.5	(						
3-5	PAC	1	(no visible floc		0.48	7.60	0.25	7.60	0.09
	Percol 24	0.5	(						
3-6	PAC	1	(		0.70	7.70	0.31	7.55	0.09
	Alchem 8103	0.5	(						

RESULTS

The following are the results of these jar tests:

JAR TEST RESULTS
26 February 1988

RAW WATER:

Turbidity	0.60 NTU
pH	7.9
Temperature	3.8 C
Aluminum	0.02 mg/L

Pre-chlorine dose: 1.4 mg/L

Test #1

Sample	Chemical	Dose (mg/L)	Observations: Floc	Settling	Supernatant Turb. (NTU)	Supernatant pH	Filtrate Turb. (NTU)	Filtrate pH	Al. (mg/L)
1-1	Alum	0			0.58	7.90	0.34	7.90	0.02
1-2	Alum	2	no floc visible		0.41	7.70	0.30	7.80	0.28
1-3	Alum	5	very fine floc after 10 min.	hard to see	0.46	7.75	0.26	7.60	0.42
1-4	Alum	10	small floc after 10 min.	moderate	0.38	7.52	0.23	7.25	0.37
1-5	Alum	15	small floc after 5 min.	faster	0.30	7.45	0.34	7.40	0.56
1-6	Alum	20	small floc after 5 min.	faster	0.60	7.30	0.26	7.49	0.48

Test #2

Sample	Chemical	Dose (mg/L)	Observations: Floc	Settling	Supernatant Turb. (NTU)	Supernatant pH	Filtrate Turb. (NTU)	Filtrate pH	Al. (mg/L)
2-1	PAC	0.0	(		0.56	7.9	0.32	7.75	0.03
2-2	PAC	0.2	(		0.54	8.0	0.33	7.90	0.06
2-3	PAC	0.4	(no visible floc in any sample		0.58	8.0	0.35	7.90	0.08
2-4	PAC	0.6	(		0.60	8.1	0.33	7.90	0.07
2-5	PAC	0.8	(		0.61	7.8	0.32	8.10	0.11
2-6	PAC	1.0	(		0.53	8.1	0.33	8.00	0.15

Test #3

Sample	Chemical	Dose (mg/L)	Observations: Floc	Settling	Supernatant Turb. (NTU)	Supernatant pH	Filtrate Turb. (NTU)	Filtrate pH	Al. (mg/L)
3-1	Alum	5	fine floc after 5 min.	(same	0.42	7.75	0.27	8.00	0.47
	Chargepac 8	0.5		(as					
3-2	Alum	5	small floc after 5 min.	(w/o	0.40	7.50	0.17	7.90	0.40
	Percol 24	0.5		(polymer					
3-3	Alum	5	small floc after 5 min.	(	0.42	7.70	0.23	7.70	0.34
	Alchem 8103	0.5							
3-4	PAC	1	(		0.50	7.45	0.33	7.50	0.10
	Chargepac 8	0.5	(						
3-5	PAC	1	(no visible floc		0.48	7.60	0.25	7.60	0.09
	Percol 24	0.5	(						
3-6	PAC	1	(		0.70	7.70	0.31	7.55	0.09
	Alchem 8103	0.5	(						

CONCLUSIONS

Slightly lower filtered water turbidity levels were obtained using alum (as compared to PAC), but the aluminum concentration in the alum samples were higher. The PAC did not form any visible floc. The best result obtained in terms of filtrate turbidity was with 5 mg/L alum and 0.5 mg/L Percol LT 24, but the aluminum content of this sample was quite high.

It should be noted that these tests do not reproduce plant conditions exactly. The mixed media filter in the plant would retain smaller particles than the Whatman 41 filter. The results for these tests could be used for comparative and qualitative purposes, and as a starting point for full-scale tests.

APPENDIX C

DAILY LOG

WATER WORKS PURIFICATION PLANT

REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
DEPARTMENT OF ENGINEERING
FILTER BUILDING LOG

ALUM 5.0 mg/l
19:00 7.5 mg/l

DATE JAN 2 1987

FILTER LOSS OF HEAD

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
6												O/S												O/S
Mn	1.1	1.9	C	C	1.7	3.4	1.8	4.5	4.8	5.4	1.3		3.0	0.7	1.7	3.7	C	2.9	1.6	C	C	2.7	5.7	
1	1.4	1.9			1.7	3.5	1.8	4.7	5.0	6.6	1.4		2.1	0.7	1.8	3.8		3.0	1.6			3.8	5.8	
2	1.5	2.0			1.7	3.6	1.8	5.0	5.1	5.8	1.5		2.2	0.8	1.9	2.9		3.1	1.7			3.9	6.0	
3	1.5	2.0			1.7	1.9	1.8	5.2	5.3	6.0	1.7		3.2	0.9	1.9	3.9		3.2	1.8			4.0	6.1	
4	1.5	2.0			1.8	4.2	1.9	5.5	5.5	6.2	1.9		3.3	1.0	2.0	4.0		3.3	1.9			4.1	6.3	
5	1.5	2.1			1.8	4.3	1.9	5.7	5.7	6.3	1.9		3.3	1.0	2.0	4.0		3.4	1.9			4.2	6.4	
6	1.6	2.2			1.9	4.4	1.9	5.8	5.8	6.4	2.0		3.4	1.0	2.0	4.1		3.5	2.0			4.3	6.5	
7	1.6	2.2			1.9	4.6	1.9	6.0	6.0	6.6	2.1		3.5	1.0	2.0	4.1		3.6	2.0			4.4	6.6	
8	1.6	2.3			2.0	4.7	2.0	6.1	6.1	6.8	2.2		3.6	1.1	2.1	4.2		3.7	2.1			4.5	6.7	
9																								
10																								
11																								
Noon																								
1																								
2																								
3																								
4																								
5																								
6	15	22			20	49	19	62	63	69	23		36	1.1	21	42	06	37	21			43	64	
7	15	23			20	50	20	63	64	70	23		36	11	21	4.7	06	37	22			43	64	
8	15	23			20	51	20	64	65	72	24		37	11	22	44	06	37	22			44	65	
9	15	23			21	52	21	65	66	74	25		37	1.1	22	45	07	38	22			44	65	
10	15	23		15	21	53	21	66	66	75	26		37	11	22	45	07	38	22			44	65	
11	15	23		16	22	54	22	67	67	[illegible]	26		[illegible]	11	2[illegible]	45	07	38	22			45	66	
Mn	15	21		16	22	54	22	67	67		23		36	1.1	22	45	07	39	23			45	66	

Hourly Log

Hour	Total Filter Rate MGD	Water Level Filt.	Water Level Cw.	Lake	Chlorine Pre Dose PPM	Pre Roto Meter	Pre Scale	Pre Roto Meter	Post Scale 1	Post Roto Meter	Post Scale 2	Post Roto Meter	SO2 Scale 1	SO2 Roto Meter	SO2 Scale 2	SO2 Roto Meter	NH3 P.P.M. R.W.	NH3 Rate Lb/24 Hr	Fluorine Added 2020 Scale	H2SiF6 Lb/Hr	Fluoride P.P.M.	Turb. NTU R.W.	Turb. NTU C.W.	Cl2 Plant Res. P.P.M.	Water Temp. °C
Mn	102.0	-.60	8.1	79	1.6	900		200					1850		1505		.01	204	2510	165	.99	2.6	.20	.89	4
1	102.0	-.60	8.1	107													.01	200	3340	170	1.02				
2	102.0	-.60	8.1	105	1.6	900		800/700									-	200	3170	170	1.02	2.4	.20	.86	4
3	102.0	-.60	8.1	104													.01	200	3010	160	.96				
4	102.0	-.60	8.1	105	1.5	900		700									.01	200	2850	160	.96	2.8	.20	.87	4
5	102.0	-.60	8.1	105													.01	200	2690	160	.96				
6	102.0	-.60	8.1	106	1.5	900		700										200	2530	160	.96	3.6	.20	.87	4
7	102.0	-.65	8.1	102														200	2385	145	.87				
8	Ø	Ø	8.1	78	-	OFF		OFF										200	2240	145	.87	-	-	—	4
9																		OFF							
10																									
11																									
Noon																									
1																									
2																									
3							on 400		400 on																
4							OFF		OFF																
5																									
6	108.0					900		800		on 100		on 100							4260						
7	108.0	-	7.9	83						"		"					.05	220	4210	50	—				
8	108.0	-.70	8.0	110	1.6	700		800		OFF		OFF					.06	220	4050	160	.96	5.7	.43	.82	4
9	108.0	-.60	8.0	111													-	220	3885	165	.99				
10	108.0	-.60	8.0	107	1.6	900/1000		800/900									.08	220	3715	170	1.02	6.1	.43	.80	4
11	108.0	-.60	8.0	107													.08	220	3550	165	.99				
Mn	108.0	-.60	8.0	107	1.8	1000/1100		900/1000		on 100		on 100					.09	220	3385	165	.99	6.0	.43	.74	4

1464 ← 6700 + 5800 = 12500 × 2 = 25000 ÷ 24 = 1040 2720 2145 4.93

Filter Washes

No.	Loss	Time Off	Hrs. Fwd.	Hrs. Run	When	By	Gals x 1000	Rate	Venturi	Hrs. Non. Wash	Hrs. Wash Mon.
1			34								14
2			9								14
3			0								0
4			0								2
5			38								14
6			24								14
7			43								14
8			28								14
9			52								14
10	7.5	2200	49	61	2200	Bm	115	12.75	0115	12	0
11			5								14
12			0								0
				61			115			12	114
			303								

No.	Loss	Time Off	Hrs. Fwd.	Hrs. Run	When	By	Gals x 1000	Rate	Venturi	Hrs. Non. Wash	Hrs. Wash Mon.
13			35								14
14			20								14
15			20								14
16			24								14
17			0								6
18			24								14
19			17								14
20			0								0
21			0								0
22			24								14
23			46								14
24			2								0
				0			0			6	118
			241								

Wash Water

Time	L.L.	H.L.	Wash W. Pumps
20:00		100	123
0745		Ø	Ø
1515		100	244

R.W. Total	62,05 0,000
	59930,000
R.W. Yesterday	54 74 0,000
W.W. Used	115,000
	54855,000
C.W.R.	+
Total F.W.	54855,000
W.W. Venturi Mdn.	0115 000
W.W. Venturi Mdn.	0000 000
W.W. Used	115 000
No. of Washes	1

Summary

Pre Cl2 Dosage	1.7	P.P.M.
Pre Cl2 Used	1040	LBS.
Post Cl2 Dosage	.24	P.P.M.
Post Cl2 Used	20	LBS.
Post Cl2 Res.	.82	P.P.M.
Total Cl2 Used	1060	LBS.
	-	
NH3 Used	122	LBS.
SO2 Used	—	LBS.
SO2 Dosage	—	P.P.M.
SO2 Cyl on Hand	2	
H2SiF6 Used	2145	LBS.
Fluorine Dosage	.98	P.P.M.
Filter Rate	61	M.G.D.
Filter Hours	244	
Avge. Filter Runs	61	HRS
Avge. Water Temp.	4	°C

Operators	
12-7	[illegible signature]
7-7	[illegible signature]
7-12	[illegible signature]

1/2 5075

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

WATER WORKS PURIFICATION PLANT

LOW LIFT PUMPING STATION

DATE: JAN 2 1987

TIME	MODULE 1 INTEGRATOR X 10,000	MODULE 2 INTEGRATOR X 10,000	WATER HOURLY PUMPAGE	WATER RATE M.G.D.	ELEV. WET WELL	MOD. 1 VALVE POS.	MOD. 2 VALVE POS.	MOD. 1 RATE M.G.D	MOD. 2 RATE M.G.D
	9423950	9136748							
0100	9424209	9136936	4470	107.28		37	45	62.16	45.12
0200	9424469	9137120	4430	106.32		37	43	62.16	44.16
0300	9424724	9137305	4410	105.84		37	44	61.44	44.40
0400	9424980	9137487	4380	105.12		36	43	61.44	43 68
0500	9425256 / 1326	9137670 / 432	4376 / 32076	105.36		35	43	61.44	43.92
0600	9425494	9137859	4420	106.08		35	43	61.92	44.16
0700	9425744	9138030	4160	102.24		36	43	60.00	41.11
0800	9425530	9138166	3220	77.28		36	43	44.64	32.64
0900									
1000									
1100									
1200									
1300									
1400									
1500									
1600									
1700	9426048 / 1098	9138250 / 1501	2010 / 36000	118.18		33	44	28.32	20.16
1800	9426048	9138250	0	0		33	44	0	0
1900	9426233	9138413	3480	83.52		24	42	44.40	39.12
2000	9426505	9138599	4580	109.92		37	45	65.28	44.64
2100	9426771	9138795	4620	110.88		37	47	63.84	47.04
2200	9427025	9138988	4470	107.28		39	48	60.96	46.32
2300	9427275	9139183	4450	106.80		38	44	60.00	46.80
2400	9427525 / 3575	9139378 / 2630	4450 / 62050	106.80		38	44	60.00	46.80

ELAPSED TIME

L1 L2 L3 ON
07:43 2:1:2:8:55:

15:50:12 ON
16:15:13:00

1815 L1 2 3 ON

PUMP NO.	L1	L2	L3	L4	L5	L6	L7	L8
2400	796.7	828.0	88.4	1439	/	/	822.7	662.7
2400	783.3	817.2	87.4	1439	/	/	832.7	655.0
HOURS RUN	13.4	14.8	5.8	—	/	/	—	6.7

OPERATOR NIGHT _____ DAY JM AFT. JR

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

WATER WORKS PURIFICATION PLANT

NO. 1 DISTRICT PUMPING STATION

DATE: Friday JAN 02 1987

TIME AND OPERATORS INITIALS	INTEGRATOR X 10,000	HOURLY PUMPAGE	RATE MGD	RESERVOIR #1 LEVEL	STN PRESS	AVG VAC	AIR TEMP	2.2 KV BUS VOLTS	I.B RES.
2400	5005866			12.25					17.25
0100	5006288	4220	101.28		88	3.0		2360	
0200	5006682	3940	94.56	14.0	88	3.0		2360	17.75
0300	5007082	4000	96.00		88	3.0		2360	
0400	5007489	4070	97.68	15.25	88	3.0		2360	18.25
0500	5007892	4030	96.72		88	3.0		2360	
0600	5008301 2626	20260 4090	98.16	16.25	88	3.0		2360	18.75
0700	5008698	3970	95.28		528 88	13.0 3.0		2360	
0800	5008991 3125	2930 31250	70.32	17.75	74	2.0		2360	20.00
0900					74			2370	
1000				16.00	74			2350	20.00
1100					73			2370	
1200				14.50	73			2370	17.25
1300					73			2370	
1400				13.75	73			2370	18.75
1500					73			2370	
1600				12.50	73			2400	18.00
1700					73			2360	
1800				10.50	72	23.0		2370	18.00
1900	5009294	3030	72.72		86	3.0		2380	
2000 *	5009607	4030	96.72	11.0	86	3.0		2390	17.0
2100	5010010	4030	96.72		1693 87	3.0		2390	
2200	5010425	4150	99.60	12.0	87	3.0		2380	17.5
2300	5010837	4120	98.88		87	3.0		2390	
2400	5011250	4130	99.12	13.25	87	3.0		2360	18.0
TOTALS	EST. 54740				1941	41.0			
AVERAGE					81	2.9			

* EST

PUMP #	1-1 C.O	1-2 2.3	1-3 4.3	1-4 4.3	1-5 4.3	1-6 2.3	COMMENTS
2400	384.0	594.9	809.2	202.1	71.8	893.5	18.15 = +2, 1-3, 1-4 ON
2400	384.0	581.5	795.9	185.6	71.8	893.5	
HOURS RUN	-0-	13.4	13.3	13.5	-0-	-0-	

STELCO (x 1000)

4235988 2400

4231015 2400

OPERATOR

NIGHT TM

DAY

MAX. HOURLY PUMPAGE

4.220 000 GALS.

THE REGIONAL MUNICIPALITY OF HAMILTON WENTWORTH

DEPARTMENT OF ENGINEERING

REGIONAL LABORATORIES

WATER PURIFICATION PLANT - DAILY INSPECTION

Date: Jan 2/87 Hour: 0200 By: NDS

CHLORINE RESIDUALS:

SAMPLE POINT	ANALYSES		RECORDER		ODOUR
	Free	Total	Indic.	Control Point	
Pre-Chlorine Module 1	.24 .96	1.17	1.10	1.34	
Pre-Chlorine Module 2	1.13 1.35	1.48	1.34	1.20	
Post-Chlorine Module 1	.00	.67	Offsc.	.53	
Post-Chlorine Module 2	.00	.97	.7(±.1)	.48	
H.L. Recorder	.00	.85	.80	—	

Chlorine Dose _____ Ammonia Yes

Turbidity 3.83 SO_2 No

Alum _____ Water Temperature 4°C

WATER WORKS PURIFICATION PLANT

MONTHLY REPORT

PUMPAGE gallons x 1000

DATE	LOWLIFT	LEAKAGE & REFILLS	DISTRICT	DISTRICT 8 1	DISTRICT 1 18	PRE-TREATMENT Cl2 kg	Cl2 mg/L	ALUM kg	ALUM mg/L	TURB. N.T.U.	FILTERED GALLONS x 1000	TOTAL FILTER HOURS	AVERAGE FILTER RUN E	AVERAGE FILTER RUN W	WASHES #	WASHES W.W.USED x 1000	WASHES I	POST TREATMENT Cl 2 kg	Cl 2 mg/L	NH 3 kg	NH 3 mg/L	SO2 kg	SO2 mg/L	H2SiF6 kg	H2SiF6 mg/L	Cl 2 PLANT Res.mg/L	Average Water Temp.C
01-Nov-86	95520	2745	91360	18.0	20.8	818	1.9	1690	3.9	1.3	92775	384	48	61	10	1355	1.4	0	0.00	91	0.22	0	0.00	1648	3.97	0.87	11
02-Nov-86	90000	2790	86610	24.5	30.0	818	2.0	1495	3.7	1.2	87210	384	35	61	4	540	0.6	0	0.00	91	0.23	0	0.00	1614	4.10	0.84	11
03-Nov-86	45120	2200	42530	21.0	26.3	466	2.3	715	3.5	1.1	42920	189	66	55	3	390	0.9	0	0.00	45	0.23	0	0.00	768	3.97	0.82	11
04-Nov-86	57500	5030	51390	20.0	24.8	511	2.0	975	3.7	1.1	52420	224	54	63	8	1030	2.0	11	0.05	54	0.23	0	0.00	893	3.84	0.75	11
05-Nov-86	57510	5580	51210	19.3	23.0	511	2.0	1040	4.0	1.7	51930	224	40	50	5	720	1.4	7	0.03	54	0.23	0	0.00	918	3.94	0.85	10
06-Nov-86	57510	5580	51210	19.3	23.0	511	2.0	1625	6.4	1.6	52230	224	72	38	2	270	0.5	7	0.03	53	0.23	0	0.00	882	3.75	0.85	10
07-Nov-86	55970	3740	51960	18.0	21.8	511	2.0	1625	6.4	1.6	50445	224	33	57	4	535	1.1	0	0.00	53	0.23	0	0.00	925	4.07	0.85	9
08-Nov-86	50760	515	49850	15.3	21.0	518	2.2	975	4.2	2.2	84195	384	45	46	15	1755	2.1	0	0.00	91	0.24	0	0.00	1525	4.07	0.91	9
09-Nov-86	95380	9685	82380	19.8	29.0	795	1.9	2275	5.3	2.9	67335	313	40		4	575	0.9	18	0.06	70	0.23	0	0.00	1302	4.30	0.81	9
10-Nov-86	74150	6795	66640	24.8	29.8	675	2.0	2925	8.7	2.2	46725	224	45	60	2	275	0.6	15	0.07	53	0.25	0	0.00	907	4.28	0.84	9
11-Nov-86	69400	2675	66630	20.3	27.5	501	2.2	2015	9.0	1.3	40510	194	47	61	7	960	2.0	8	0.04	45	0.21	0	0.00	818	3.78	0.71	9
12-Nov-86	51750	3240	47610	16.0	24.5	473	2.0	910	3.9	1.3	45605	184	34	52	7	895	1.9	18	0.09	42	0.21	0	0.00	839	4.13	0.70	9
13-Nov-86	50260	4655	44660	15.0	19.5	480	2.1	845	3.7	1.1	48490	224	44		1	130	0.2	20	0.09	49	0.22	0	0.00	905	4.11	0.77	8
14-Nov-86	57780	9220	48420	10.8	17.5	477	1.8	1105	4.2	1.5	52395	224	37		6	805	1.5	29	0.12	53	0.23	0	0.00	909	3.88	0.80	8
15-Nov-86	57050	4655	51590	9.5	15.8	520	2.0	1105	4.3	1.2	94765	384	47	58	9	1255	1.5	0	0.00	91	0.21	0	0.00	1564	3.68	0.81	8
16-Nov-86	93450	3685	95390	18.0	18.0	800	1.8	1820	4.1	1.2	90360	384	37	72	8	1170	1.3	0	0.00	91	0.22	0	0.00	1545	3.79	0.84	8
17-Nov-86	93340	4980	82630	25.5	24.5	750	1.7	1835	4.3	1.1	43065	224	30		4	495	1.0	0	0.00	53	0.25	0	0.00	825	3.81	0.82	8
18-Nov-86	50450	2385	47650	19.8	27.0	477	2.1	975	4.3	1.1	48060	208	41	50	7	1050	2.3	0	0.00	49	0.24	0	0.00	730	3.90	0.83	8
19-Nov-86	48320	2260	45010	16.5	22.3	450	2.0	585	2.7	2.0	47670	208	33	51	5	720	1.5	0	0.00	49	0.23	0	0.00	820	3.84	0.84	7
20-Nov-86	52100	4110	47050	15.0	19.3	486	2.1	780	3.3	2.2	48610	208	46		1	170	0.4	0	0.00	49	0.22	0	0.00	852	3.87	0.84	7
21-Nov-86	50900	2290	48440	11.5	17.0	507	2.2	585	2.5	2.4	51950	224	22	43	4	590	1.1	0	0.00	55	0.25	0	0.00	845	3.62	0.85	6
22-Nov-86	53550	1600	51420	11.0	15.0	491	2.0	1560	6.4	2.1	92110	384	69	63	5	710	0.8	0	0.00	91	0.22	0	0.00	1652	3.95	0.91	7
23-Nov-86	94110	2000	91400	15.5	20.0	750	1.8	2470	5.8	1.5	89325	384	72	51	10	1515	1.5	0	0.00	91	0.23	0	0.00	1520	3.80	0.85	7
24-Nov-86	93550	4005	86010	25.8	27.0	750	1.8	1365	3.2	1.8	51185	208	41		2	285	0.6	0	0.00	49	0.21	0	0.00	739	3.19	0.82	6
25-Nov-86	52560	1175	50900	18.0	27.0	450	1.9	715	3.0	2.0	50835	224	43	72	4	585	1.20	0	0.00	55	0.23	0	0.00	909	3.98	0.85	7
26-Nov-86	52960	2125	50250	17.0	25.0	473	2.0	650	2.7	1.5	49255	224	40	54	5	755	1.5	7	0.03	53	0.24	0	0.00	918	4.16	0.87	7
27-Nov-86	51850	2595	48300	14.3	20.5	466	2.0	650	2.8	1.5	52200	224	45	63	7	1050	2.0	0	0.00	55	0.23	0	0.00	884	3.91	0.87	6
28-Nov-86	56150	5950	51110	12.3	18.0	484	1.9	650	2.5	1.6	50740	224	47	72	3	430	0.8	0	0.00	55	0.23	0	0.00	877	3.84	0.85	6
29-Nov-86	54100	3680	50310	11.3	16.5	432	1.9	780	3.2	1.3	87710	384	59	72	5	640	0.7	0	0.00	91	0.25	0	0.00	1652	4.12	0.84	6
30-Nov-86	91680	6970	87070	14.0	22.3	700	1.6	1430	3.3	1.4	89770	384	49	72	8	1070	1.2	0	0.00	13	0.05	0	0.00	1570	3.90	0.57	6
TOTAL	1978850	114535	1841700			17274		38025			1864315	8030			163	22555		140		1827		0		32782			
MIN	45120	515	42530	10	15	450	1.6	585	2.5	1.1	42920	184	22	30	1	130	0.2	0	0.00	0	0.00	0	0.00	0	0.00	0.70	6
AVE	65962	3818	61390	17	23	576	2.0	1268	4.2	1.7	62144	269	45	58	5	752	1	5	0	59	0	0.00	1057	3.77	0.82	7
MAX	93450	9685	95390	25	30	813	2.3	2925	9.0	3.7	94765	384	72	72	15	1755	2.3	29	0.12	91	0.25	0	0.00	1648	4.30	0.91	0

DEPARTMENT OF ENGINEERING

WATER PURIFICATION PLANT

UTILITIES AND MATERIALS CONSUMPTION

MONTH OF NOVEMBER 1986

WEEK BEGINNING	HYDRO ELECTRIC DOLLARS	STEAM	LOW LIFT PUMPAGE MJ	ALUM Dry kg	ALUM mg/L	CHLORINE kg	CHLORINE mg/L	AMMONIA Kg	AMMONIA mg/L	FLUORIDE kg	FLUORIDE mg/L	AV. TURBIDITY NTU RAW WATER	AV. TURBIDITY NTU FIN. WATER
NOV 1 1986			843273	3182	3.8	1636	1.9	182	0.22	3261	1.01	1.3	0.29
NOV 3 1986			1975723	10584	5.4	3989	2.0	420	0.23	7214	1.00	1.9	0.30
NOV 10 1986			2093318	9675	4.6	4082	2.0	424	0.20	7469	0.89	1.2	0.24
NOV 17 1986			2012545	8312	4.1	3911	1.9	435	0.22	7293	0.91	1.9	
NOV 23 1986			2070930	6299	3.0	3736	1.8	365	0.18	7530	0.91	1.7	
MONTHLY TOTAL	65416	1664000	8995789	38052	3.5	17354	1.9	1826	0.21	32767	0.94	1.6	0.28
% of 1985	109	125	106	83		94		109		114			
TOTAL TO DATE	744050	13097000	90547168	295358		213321		20598		368255			
% of 1985	102	105	80	81		100		104		96			
ANNUAL ALLOCATION	$ 800 000	14 253 800		390 000		230 000		21 300		415 000			

APPENDIX D

PLANT WASTE STUDY

PLANT WASTE STUDY

TERMS OF REFERENCE

A Plant Waste Study was required as part of the Water Plant Optimization Study. The Terms of Reference for this part of the project are:

1. Document the origin, amount and quality of sludge, screenings, etc. produced at the water treatment plant.

2. Document the volume and quality of filter backwash produced at the water treatment plant. Include at least 3 years of data, if available. If wastewater treatment exists at the plant the raw and treated qualities should be documented.

3. Document the present methods of disposal of the water plant wastewaters.

4. Identify likely alternative methods of treatment/disposal of wastewater along with associated cost estimates.

BACKGROUND

The Hamilton-Wentworth Water Treatment Plant is a conventional facility utilizing coagulation, sedimentation and filtration. Figure 1 is a schematic of the treatment processes. It is a large plant, treating an average of approximately 300,000 m^3/d and serving a population of 385,000. To save on hydro costs, the plant operates only at night Monday to Friday and 24 hours per day from Friday night to Monday morning.

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
WATER TREATMENT PLANT

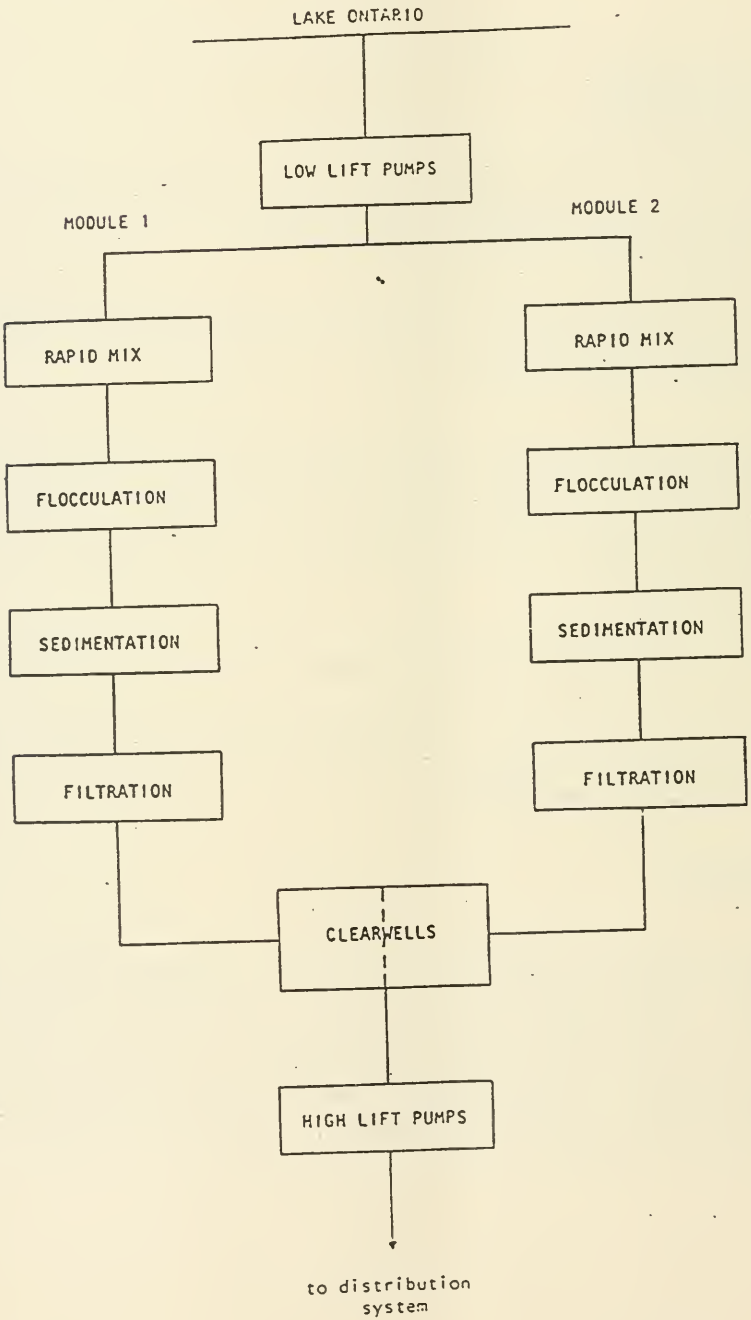


FIGURE 1
Process Block Schematic

The plant waste is from three sources. The current disposal systems are as follows:

Source	Disposal
Screens	Discharge to Red Hill Creek
Backwash and Sedimentation Tank Sludge	Discharged to sewer for treatment at the Sewage Treatment Plant

An extensive study of the plant waste was conducted in 1979 by James F. MacLaren Limited ("Preliminary design of a Wastewater Management System for the Hamilton Water Purification Plant"). Prior to this study being conducted all of the water plant waste was discharged to Red Hill Creek which flows into the Hamilton Harbour. The MacLaren study recommended that a sewer be constructed to carry backwash water and sedimentation sludge to the Woodward Avenue S.T.P. located next door to the water plant. This recommendation was carried out.

CURRENT CONDITIONS

The average daily volume of backwash wastewater produced over the years 1984 to 1985 was 5265 m^3. A change in the operation of the water plant, the lengthening of the filter runs form 36 to 72 hours, has reduced the volume of backwash water. The mean daily volume in 1986 was 3055 m^3/d, a reduction of 42%.

A study of the suspended solids content of the backwash water was conducted in January-February, 1988. Grab samples of the wastewater were taken four times during backwash cycles. The four samples were mixed to form a composite for the suspended solids analysis. The mean suspended solids content was 520 mg/L.

Although the suspended solids content of the backwash water is high, it does not appear to cause any problems at the sewage treatment plant. The average daily flow at the Woodward Avenue S.T.P. for 1984 to 1986 was 313,000 m^3/d.

Thus, the backwash water is less than 1% of the daily flow. As well, backwashes are usually only done at night and on weekends which would not coincide with peak flows to the sewage plant.

The sedimentation tanks are cleaned approximately every 3 months when 3 to 5 cm of sludge has accumulated. Only one basin is cleaned at a time, leaving 3 in operation. Approximately 4 m of settled water from the top of the tank is discharged to Red Hill Creek and the remaining water and sludge is sent to the sewage treatment plant. The sludge is flushed with high pressure hoses.

The suspended solids in a sample of settled water were also measured during the 1988 study with the following results:

Mean	3.5 mg/L
Range	0.4-12.6 mg/L

These results are below the MOE objective for suspended solids in effluent (15 mg/L).

The volume of the sludge discharged during cleaning is not measured. The 1979 MacLaren study found the average volume of sludge and cleaning water form one tank was 1240 m^3. The sewage treatment plant does not report any operational problems caused by the alum sludge.

There is no qualitative information available on the screening waste from the Low Lift station.

CONCLUSIONS

The current waste disposal system for backwash water and sediment in tank sludge is operating effectively and without problems. A review of the screenings disposal system may be necessary if the MOE expresses concern with the current practice of discharging the waste to the creek.